UNIT 10: SIMPLE HARMONIC MOTION AND WAVES

10.1 Simple Harmonic Motion
(Mass Attached with spring; Motion of simple Pendulum only)
10.3 Wave Motion
10.4 Types of mechanical waves

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 1
BASED ON UNIT # 10 ([illegible])
SIMPLE HARMONIC MOTION AND WAVES

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. Which of the following is an example of simple harmonic motion?

A. Motion of a simple pendulum B. The motion of ceiling fan
C. The spinning of the Earth on its axis D. A bouncing ball on a floor.

ii. If the mass of the bob of a pendulum is increased by a factor of 3, the period of the pendulum's motion will

A. be increased by a factor of 2 B. remain the same
C. be decreased by a factor of 2 D. be decreased by a factor of 4

iii. Which of the following devices can be used to produce both a transverse and longitudinal waves?

A. a string B. a ripple tank
C. a helical spring (slinky) D. a tuning fork

iv. Waves transfer

A. energy B. frequency
C. wavelength D. velocity

v. Which of the following is a method of energy transfer?

A. Conduction B. Radiation
C. Wave motion D. All of these

vi. In a vacuum all electromagnetic waves have the same

B. frequency

vii. **Waves which require medium for propagation are**
A. electromagnetic B. mechanical
C. transverse D. longitudinal

viii. **Which of the following characteristics of a wave is independent of the others?**
A. speed B. frequency
C. Amplitude D. wavelength

ix. **The relation between v , f and λ of a wave is**
A. $v f = \lambda$ B. $f \lambda = v$
C. $v \lambda = f$ D. $v = \lambda / f$

x. **A human eardrum can oscillate back and forth in one second up to:**
A. 200 times B. 2000 times
C. 20 times D. 20,000 times

xi. **The maximum displacement of a vibrating body in one second is called.**
A. frequency B. Amplitude
C. vibration D. Displacement

xii. **When water waves enter the region of shallow water their wavelength?**
A. Increases B. Remains same
C. Decreases D. Not effected

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet-B if required. Write your answers neatly and legibly.

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. **What is simple harmonic motion? What are the necessary conditions for a body to execute simple harmonic motion?**

ii. **If 100 waves pass through a point of a medium in 20 seconds, what is the frequency and the time period of the wave? If its wavelength is 6 cm, calculate the wave speed.**

iii. **How can you define the term wave? Elaborate the difference between mechanical and electromagnetic waves? Give examples of each.**

iv. **Find the time periods of a simple pendulum of 1 metre length, placed on Earth and on moon. The value of g on the surface of moon is 1/6th of its value on Earth. Where g_e is 10 ms^{-2}.**

v. **Draw a transverse wave with an amplitude of 2 cm and a wavelength of 4 cm. Label a crest and trough on the wave.**

vi. **Derive a relationship between speed, frequency and wavelength of a wave. Write a formula relating speed of a wave to its time period and wavelength.**

vii. **Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment.**

viii. **The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on the moon if $g_m = g_e / 6$? Where g_e = 10ms^{-2}.**

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. **Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related?**

ii. **If the length of a simple pendulum is doubled what will be the change in its time period?**

iii. **A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion of the ball simple harmonic? Explain.**

iv. A student performed two experiments with a simple pendulum. He/She used two bobs of different masses by keeping other parameters constant. To his/her astonishment the time period of the pendulum did not change! Why?

v. What types of waves do not require any material medium for their propagation?

vi. Find the time period and frequency of a simple pendulum 1.0 m long at a location where g = 10.0 ms^{-2}.

vii. A wave moves on a slinky with frequency of 4 Hz and wavelength of 0.4 m. What is the speed of the wave?

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. $(2 \times 10 = 20)$

Q4. a. Distinguish between longitudinal and transverse waves with suitable examples.

b. A simple pendulum completes one vibration in two seconds. Calculate its length when $g = 10.0$ ms^{-2}.

Q5. a. Show that the motion of a mass attached to the end of a spring is simple harmonic motion (SHM).

b. What is the wavelength of the radio waves transmitted by an FM station at 90 MHz? Where 1M = 10^6, and speed of radio wave is 3×10^8 ms^{-1}

Q6. a. What is simple pendulum? Illustrate diagrammatically the forces acting on the bob of a simple pendulum. Prove that the component of the weight responsible for the vibration of the pendulum is always directed towards the equilibrium position?

OR

Prove that vibratory motion of simple pendulum is SHM?

b. A pendulum of length 0.99 m is taken to the moon by an astronaut. The period of the pendulum is 4.9 s. What is the value of g on the surface of the moon?

Solution of Guess Paper & Model Paper # 1

(Reduced Syllabus)

SECTION- A (MCQs)

i. A	ii. B	iii. C	iv. A	v. D	vi. A
vii. B	viii. C	ix. B	x. D	xi. B	xii. C

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. $(6 \times 3 = 18)$

i. What is simple harmonic motion? What are the necessary conditions for a body to execute simple harmonic motion?

Ans: **Simple harmonic motion (SHM):-**

Simple harmonic motion (SHM) is a to and fro oscillatory motion in which acceleration of the body is directly proportional to the displacement of the body from the mean position and is always directed towards the mean position.

$$acceleration \propto -displacement$$

$$a \propto -x$$

Negative sign indicates that acceleration and displacement are opposite in direction.

Basic conditions to execute simple harmonic motion (SHM):

Basic conditions to execute simple harmonic motion are as under:

(i) There must be an elastic restoring force acting on the system.

ختم نبوت ﷺ زندہ باد | **عظمت صحابہ زندہ باد**

السلام علیکم ورحمۃ اللہ وبرکاتہ:

معزز ممبران: آپ کا وٹس ایپ گروپ ایڈمن "**اردو بکس**" آپ سے مخاطب ہے۔

آپ تمام ممبران سے گزارش ہے کہ:

- گروپ میں صرف PDF کتب پوسٹ کی جاتی ہیں لہذا کتب کے متعلق اپنے کمنٹس / ریویوز ضرور دیں۔ گروپ میں بغیر ایڈمن کی اجازت کے کسی بھی قسم کی (اسلامی وغیر اسلامی، اخلاقی، تحریری) پوسٹ کرنا سختی سے منع ہے۔
- گروپ میں معزز، پڑھے لکھے، سلجھے ہوئے ممبرز موجود ہیں اخلاقیات کی پابندی کریں اور گروپ رولز کو فالو کریں بصورت دیگر معزز ممبرز کی بہتری کی خاطر ریمو کر دیا جائے گا۔
- کوئی بھی ممبر کسی بھی ممبر کو انباکس میں میسج، مس کال، کال نہیں کرے گا۔ رپورٹ پر فوری ریمو کر کے کاروائی عمل میں لائے جائے گی۔
- ہمارے کسی بھی گروپ میں سیاسی و فرقہ واریت کی بحث کی قطعاً کوئی گنجائش نہیں ہے۔
- اگر کسی کو بھی گروپ کے متعلق کسی قسم کی شکایت یا تجویز کی صورت میں ایڈمن سے رابطہ کیجئے۔
- سب سے اہم بات:

گروپ میں کسی بھی قادیانی، مرزائی، احمدی، گستاخِ رسول، گستاخِ امہات المؤمنین، گستاخِ صحابہ و خلفائے راشدین حضرت ابو بکر صدیق، حضرت عمر فاروق، حضرت عثمان غنی، حضرت علی المرتضیٰ، حضرت حسنین کریمین رضوان اللہ تعالیٰ اجمعین، گستاخ اہلبیت یا ایسے غیر مسلم جو اسلام اور پاکستان کے خلاف پراپیگنڈا میں مصروف ہیں یا ان کے روحانی وذہنی سپورٹرز کے لئے کوئی گنجائش نہیں ہے لہذا ایسے اشخاص بالکل بھی گروپ جوائن کرنے کی زحمت نہ کریں۔ معلوم ہونے پر فوراً ریمو کر دیا جائے گا۔

- تمام کتب انٹرنیٹ سے تلاش / ڈاؤنلوڈ کر کے **فری آف کاسٹ** وٹس ایپ گروپ میں شیئر کی جاتی ہیں۔ جو کتاب نہیں ملتی اس کے لئے معذرت کر لی جاتی ہے۔ جس میں محنت بھی صَرف ہوتی ہے لیکن ہمیں آپ سے صرف دعاؤں کی درخواست ہے۔
- عمران سیریز کے شوقین کیلئے علیحدہ سے عمران سیریز گروپ موجود ہے۔

لیڈیز کے لئے الگ گروپ کی سہولت موجود ہے جس کے لئے ویریفکیشن ضروری ہے۔

- اردو کتب / عمران سیریز یا سٹڈی گروپ میں ایڈ ہونے کے لئے ایڈمن سے وٹس ایپ پر بذریعہ میسج رابطہ کریں اور جواب کا انتظار فرمائیں۔ برائے مہربانی اخلاقیات کا خیال رکھتے ہوئے موبائل پر کال یا ایم ایس کرنے کی کوشش ہر گز نہ کریں۔ ورنہ گروپس سے تو ریمو کیا ہی جائے گا بلاک بھی کیا جائے گا۔

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اللہ تبارک تعالیٰ ہم سب کا حامی و ناصر ہو

(iii) The acceleration of the system should be directly proportional to its displacement and is always directed to mean position i.e. $a \propto -x$

ii. If 100 waves pass through a point of a medium in 20 seconds, what is the frequency and the time period of the wave? If its wavelength is 6 cm, calculate the wave speed.

Solution: Number of waves passed = 100 waves ; Time taken = 20 sec ; Frequency = ?

Wavelength $\lambda = 6 \text{ cm} = \frac{6}{100} = 0.6 \text{ cm}$; Wave speed v=?

$$\text{Frequency} = \frac{number\ of\ waves\ passed}{time\ taken} = \frac{100}{20} = 5\text{Hz}$$

Now $T = 1/f = 1/5 = 0.2\ sec.$

Now $v = f\lambda = 5 \times (0.6) = 0.3\ ms^{-1}$

iii. How can you define the term wave? Elaborate the difference between mechanical and electromagnetic waves? Give examples of each.

Ans: Wave:

A wave is a disturbance in the medium which causes the particles of the medium to undergo vibratory motion about their mean position in equal intervals of time.

Categories of waves: There are two categories of waves: **I.** Mechanical waves. **II.** Electromagnetic waves.

I. Mechanical waves:

Waves which require any medium for their propagation are called mechanical waves.

Examples of mechanical waves:

Examples of mechanical waves are water waves, sound waves and waves produced on the strings and springs.

II. Electromagnetic Waves:

Which do not require any medium for their propagation are called electromagnetic waves.

Examples of electromagnetic waves:

Radio waves, television waves, X-rays, heat and light waves are some examples of electromagnetic waves.

iv. Find the time periods of a simple pendulum of 1 metre length, placed on Earth and on moon. The value of g on the surface of moon is 1/6th of its value on Earth. Where g_e is $10ms^{-2}$.

Solution: Length L = 1m

$g_e = 10ms^{-2}$

$$g_m = \frac{g_e}{6} = \frac{10}{6} = 1.67\ ms^{-2}$$

Time period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ ....(i)

Time period on Earth $T_e = 2\pi\sqrt{\frac{L}{g_e}}$

$$T_e = 2\pi\sqrt{\frac{1}{10}}$$

$$T_e = 2 \times (3.14) \times (0.316)$$

$$T_e = 1.985\ sec$$

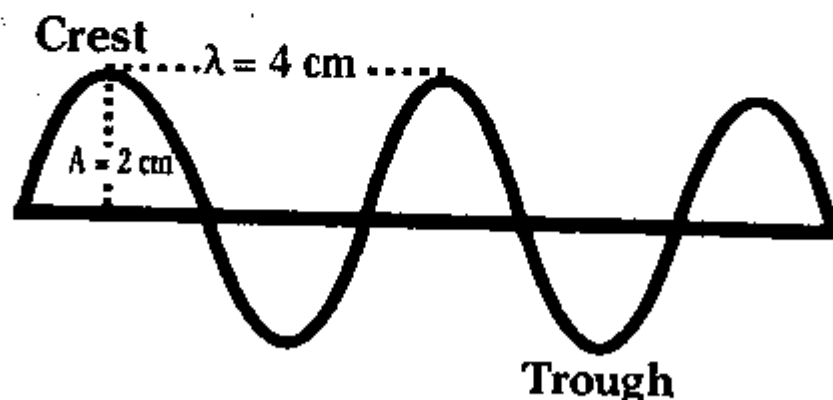
Time period on Moon $T_m = 2\pi\sqrt{\frac{L}{g_m}}$

$$T_m = 2\pi\sqrt{\frac{1}{1.67}}$$

$$T_m = 2 \times (3.14) \times (0.774)$$

$T_m = 4.9\ sec.$ is the Time Period on Moon

v. Draw a transverse wave with an amplitude of 2 cm and a wavelength of 4 cm. Label a crest and trough on the wave.

Ans:

Where "A" is Amplitude and "λ" is wavelength

vi. Derive a relationship between speed, frequency and wavelength of a wave. Write a formula relating speed of a wave to its time period and wavelength.

Ans: Wave equation:

The relation between the velocity, frequency and wavelength of the wave is known as wave equation. The velocity of wave which is defined by $Velocity = distance/time$

$$v = \frac{d}{t} \text{ .... (i)}$$

If time taken by the wave in moving from one point to another is equal to the time period then the distance covered by the wave will be equal to one wavelength, hence we can write ($d = \lambda$)

$$v = \frac{\lambda}{T} \quad \Rightarrow \quad v = \lambda \times \frac{1}{T} \text{ ....(ii)}$$

But time period T is reciprocal of the frequency f, i.e., $T = \frac{1}{f} \Rightarrow f = \frac{1}{T}$

Therefore Equation (ii) becomes $v = f\lambda$ .... (iii)

Eq. (iii) is called the wave equation.

vii. Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment.

Ans: Waves as Carriers of Energy: Energy can be transferred from one place to another through waves.

Activity/Experiment:

Drop a stone into a pond of water. Water waves will be produced on the surface of water and will travel outwards. Place a cork at some distance from the falling stone. When waves reach the cork, it will move up and down along with the motion of the water particles by getting energy from the wave.

Conclusion:

This activity shows that water waves like other waves transfer energy from one place to other without transferring matter, i.e., water.

viii. The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on the moon if $g_m = g_e/6$? Where $g_e = 10ms^{-2}$.

Time period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ ……… (i)

Squaring and arranging the equation (i) for length "l" ; $T^2 = 4\pi^2\frac{L}{g}$

$$L_e = \frac{g_e T^2}{4\pi^2} \text{ ……… (ii)} \Rightarrow L_e = \frac{10\times(2)^2}{4\times(3.14)^2} = \frac{10\times4}{4\times9.8} = \frac{10}{9.8} = 1.02\,m$$

For moon $$L_m = \frac{g_m T^2}{4\pi^2} \text{ ……… (iii)} \Rightarrow L_e = \frac{1.67\times(2)^2}{4\times(3.14)^2} = \frac{1.67\times4}{4\times9.8} = \frac{1.67}{9.8} = 0.17\,m$$

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related?

Ans: No. Increasing the frequency of a wave decreases the wavelength.

$$f = \frac{v}{\lambda} \Rightarrow f \propto \frac{1}{\lambda}$$

The two are related by the formula $v = f\lambda$ (velocity = frequency × wavelength).

ii. If the length of a simple pendulum is doubled what will be the change in its time period?

Ans: Since $T = 2\pi\sqrt{\frac{l}{g}}$ ……………(i)

When length is doubled then new length is $l' = 2l$

$$T' = 2\pi\sqrt{\frac{2l}{g}} \Rightarrow T' = 2\pi\times\sqrt{2}\sqrt{\frac{l}{g}}$$

$$T' = \sqrt{2}\times\left(2\pi\sqrt{\frac{l}{g}}\right)$$

Since by using equation (i) $T = 2\pi\sqrt{\frac{l}{g}} = \sqrt{2}T \Rightarrow T' = 1.14\,T$

If length of simple pendulum is doubled, then its time period increases by factor **1.41** times of initial time period.

iii. A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion of the ball simple harmonic? Explain.

Ans: No, because simple harmonic motion requires restoring force and acceleration be proportional to the displacement of the object the bouncing ball has constant force and acceleration regardless of displacement.

iv. A student performed two experiments with a simple pendulum. He/She used two bobs of different masses by keeping other parameters constant. To his/her astonishment the time period of the pendulum did not change! Why?

Ans: There is no effect on time period, because time period of the pendulum is independent of the mass (m).

$$(T = 2\pi\sqrt{\frac{l}{g}})$$

v. What types of waves do not require any material medium for their propagation?

vi. Find the time period and frequency of a simple pendulum 1.0m long at a location where $g=10.0\ ms^{-2}$.

Solution: Given, L= 1.0 m, g = 10.0 ms^{-2}. Using the formula, $T = 2\pi\sqrt{\frac{L}{g}}$

$$T = 2\pi\sqrt{\frac{1.0}{10.0}} = 1.99\ s.$$

And frequency of simple pendulum is given by $f = 1/T = 1/1.99 = 0.50$ Hz

vii. A wave moves on a slinky with frequency of 4 Hz and wavelength of 0.4 m. What is the speed of the wave?

Solution: Given that, $f = 4\ Hz$, $\lambda = 0.4$ m

Wave speed $v = f\lambda = (4Hz) \times (0.4m)$

$v = 1.6\ ms^{-1}$

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

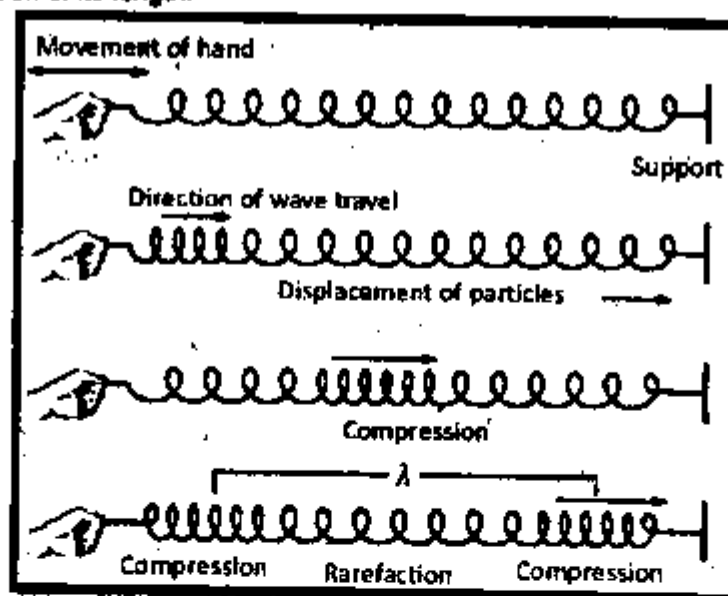
Q4. a. Distinguish between longitudinal and transverse waves with suitable examples.

Ans: Types of Mechanical Waves: Mechanical waves may be classified as longitudinal or transverse.

Longitudinal waves:

In longitudinal waves the particles of the medium move back and forth along the direction of propagation of wave.

Production of Longitudinal waves:

Longitudinal waves can be produced on a spring (slinky) placed on a smooth floor or a long bench. Fix one end of the slinky with a rigid support and hold another end into your hand. Now give it a regular push and pull quickly in the direction of its length.

Longitudinal wave on a slinky

Compressions:

A series of disturbances in the form of waves will start moving along the length of the slinky. Such a wave consists of regions called **compressions.**

Rarefactions:

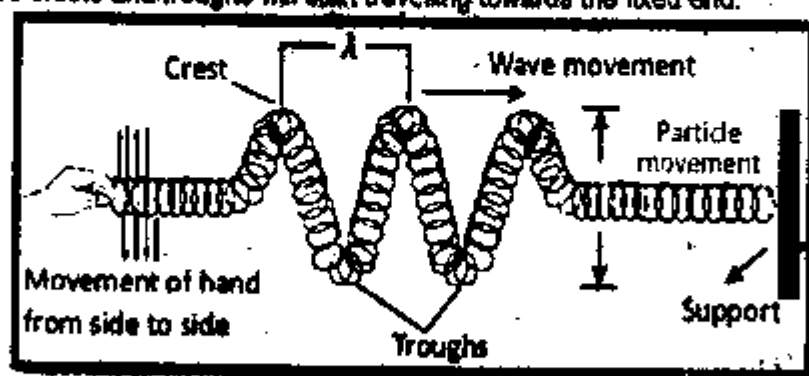
Where the loops of the spring are close together, alternating with regions called **rarefactions** (expansions), where the coils are spaced apart.

In the regions of compression particles of the medium are closer together while in the regions of rarefaction particles of the medium are spaced apart. The compressions and refractions move back and forth along the direction of motion of the wave. Such a wave is called longitudinal wave.

Transverse waves:

In the case of transverse waves, the motion of particles of the medium is perpendicular to the motion of wave.

Production of transverse waves:

We can produce transverse waves with the help of a slinky. Stretch out a slinky along a smooth floor or a long bench with one end fixed. Grasp the other end of the slinky and move it up and down quickly. A wave in the form of alternative crests and troughs will start travelling towards the fixed end.

Transverse wave on a slinky

Crests and troughs:

The crests are the highest points while the troughs are the lowest points of the particles of the medium from the mean position. The crests and troughs move perpendicular to the direction of the wave.

Waves on the surface of water and light waves are also transverse waves.

b. A simple pendulum completes one vibration in two seconds. Calculate its length when $g = 10.0\ ms^{-2}$.

Solution: Time Period T = 2 sec. ; $g_e = 10ms^{-2}$

Time Period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ ....(i)

Squaring and arranging the equation (i) for "L"

$$L_e = \frac{g_e T^2}{4\pi^2} \Rightarrow L_e = \frac{10\times(2)^2}{4\times(3.14)^2} = \frac{10\times4}{4\times9.8} = \frac{10}{9.8} = 1.02\ m$$

Q.5 a. Show that the motion of a mass attached to the end of a spring is simple harmonic motion (SHM).

Ans: See Q5. (a), Past FBISE Paper (2017), Page # 117.

b. What is the wavelength of the radio waves transmitted by an FM station at 90 MHz? Where 1M = 10^6, and speed of radio wave is $3\times10^8\ ms^{-1}$

Solution: Frequency f = 90 MHz = 90×10^6 Hz ; Speed of radio wave v = $3\times10^8\ ms^{-1}$

$$V = f\lambda \Rightarrow \lambda = \frac{c}{f} \Rightarrow \lambda = \frac{3\times10^8}{90\times10^6} \Rightarrow \lambda = \frac{10^2}{30} = \frac{100}{30} = 3.33\ m$$

Q.6 a. Prove that vibratory motion of simple pendulum is SHM?

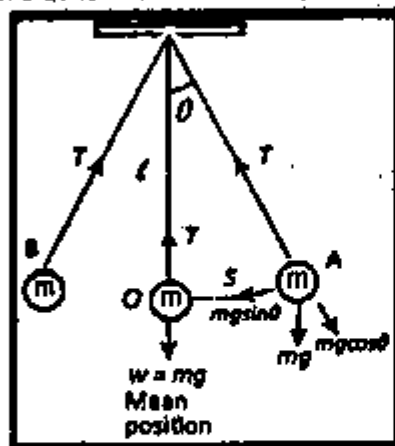
Ans: Motion of a simple pendulum:

Simple pendulum:

A simple pendulum also exhibits SHM. It consists of a small bob of mass *m* suspended from a light string of length L fixed at its upper end. In the equilibrium position O, the net force on the bob is zero and the bob is stationary.

Motion of bob from O to point A:

Now if we bring the bob to extreme position A, the net force is not zero. There is no force acting along

along this direction. The component of the weight, $mg\ sin\theta$ is directed towards the mean position and acts as a restoring force. Due to this force the bob starts moving towards the mean position O.

Forces acting on a displaced pendulum. The restoring force that causes the pendulum to undergo simple harmonic motion is the component of gravitational force mg sin θ tangent to the path of motion.

Motion of bob from O to point B:

At O the bob has got the maximum velocity and due to inertia it does not stop at O rather it continues to move towards the extreme position B. During its motion towards point B, the velocity of the bob decreases due to restoring force. The velocity of the bob becomes zero as it reaches the point B. The restoring force $mg\ sin\theta$ still acts towards the mean position O and due to this force the bob again starts moving towards the mean position O. In this way, the bob continues its to and fro motion about the mean position O.

Direction of acceleration:

It follows that the acceleration of the bob is always directed towards the mean position O. Hence the motion of a simple pendulum is SHM.

$$a \propto -x$$

Time period of simple pendulum:

We have the following formula for the time period of simple pendulum: $T = 2\pi\sqrt{\frac{L}{g}}$ .... (i)

b. A pendulum of length 0.99 m is taken to the moon by an astronaut. The period of the pendulum is 4.9 s. What is the value of g on the surface of the moon?

Solution: Length L= 0.99m ; Time period T = 4.9 sec.

Time period of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$ ... ... (i)

Squaring and arranging the equation for "g" we get $T^2 = 4\pi^2\frac{L}{g}$

$$g = 4\pi^2\frac{L}{T^2} \Rightarrow g = 4 \times (3.14)^2 \times \frac{0.99}{4.9^2} = 4 \times (9.86) \times \frac{0.99}{4.9^2}$$

$$g = 39.5 \times \frac{0.99}{24.01} = 39.5 \times 0.042 = 1.65\ ms^{-2}$$

IMPORTANT QUESTIONS & ANSWERS

Q1. A transverse wave produced on a spring has a frequency of 190 Hz and travels along the length of the spring of 90 m, in 0.5 s.
(a) What is the period of the wave? ; (b) What is the speed of the wave?
(c) What is the wavelength of the wave?

Solution: Frequency f=190 Hz ; Wavelength λ =3 cm = $\frac{3}{100} = 0.03$ m
Length of the spring = l = d = 90 m ; Time = t = 0.5 s
(a) T = ? (b) Speed v = ? (c) Wavelength λ = ?

(a) $T = \frac{1}{f} = \frac{1}{190} = 0.01\ sec.$;

(b) $v = \frac{d}{t} = \frac{90}{0.5} = 180\ ms^{-1}$

(c) $v = f\lambda \Rightarrow \lambda = \frac{v}{f} = \frac{180}{190} = 0.95\ m$

Q2. Water waves in a shallow dish are 6.0 cm long. At one point, the water moves up and down at a rate of 4.8 oscillations per second.
a. What is the speed of the water waves?
b. What is the period of the water?

Solution: Wavelength λ = 6.0 cm = $\frac{6}{100} = 0.06$ m
No. of oscillation (Frequency) = f = 4.8 Hz
(a) Speed v = ? (b) Period T = ?

$T = 1/f = \frac{1}{4.8} = 0.21\ sec.$

Now $v = f\lambda = 4.8 \times 0.06 = 0.29\ ms^{-1}$

Q3. What is the displacement of an object in SHM when the kinetic and potential energies are equal?
Ans: When the kinetic and potential energies are equal then the displacement of an object is in SHM will be $\frac{1}{\sqrt{2}} \times A$ where A is maximum displacement (amplitude)

Q4. How can you define the term vibration?
Ans: Vibration:
One complete round trip of a vibrating body about its mean position is called one vibration.

Q5. Do mechanical waves pass through vacuum, that is, empty space?
Ans: Mechanical waves require medium for their propagation.
Mechanical waves, however, are pressure fluctuations and cannot occur without a material medium to transmit them.
In the vacuum of space, there are no particles to vibrate (material medium is absent), so mechanical waves cannot pass through the vacuum.

UNIT 11: SOUND

11.1 Sound Waves
11.2 Characteristic of sound (Loudness, pitch, quality, intensity, intensity level)
11.3 Reflection of sound (Echo)
11.4 Speed of sound (Measuring speed of sound by Echo Method is excluded)
11.7 Audible frequency range
11.8 Ultra sound
(Tables: 11.1, 11.2 are included)

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 2
BASED ON UNIT # 11 (Reduced Syllabus)
SOUND

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. Which is an example of a longitudinal wave?
A. sound wave B. light wave
C. radio wave D. water wave

ii. How does sound travel from its source to your ear?
A. by changes in air pressure B. by vibrations in wires or strings
C. by electromagnetic wave D. by infrared waves

iii. Which form of energy is sound?
A. electrical B. mechanical
C. thermal D. chemical

iv. Astronauts in space need to communicate with each other by radio links because
A. sound waves travel very slowly in space B. sound waves travel very fast in space
C. sound waves cannot travel in space D. sound waves have low frequency in space

v. The loudness of a sound is most closely related to its
A. frequency B. period
C. wavelength D. amplitude

vi. For a normal person, audible frequency range for sound wave lie between
A. 10 Hz and 10 kHz B. 20 Hz and 20 kHz

vii. **When the frequency of a sound wave is increased, which of the following will decrease?**
   i. **Wavelength** ii. **Period** iii. **Amplitude**
   A. i only B. iii only
   C. i and ii only D. i and iii only

viii. **speed of sound in iron at 25 °C is?**
   A. 5950 ms^{-1} B. 4700 ms^{-1}
   C. 3980 ms^{-1} D. 1531 ms^{-1}

ix. **The intensity of the rustle of leaves is:**
   A. 0 db B. 10 db
   C. 100 db D. 20 db

x. **Speed of sound is solid in comparison to gases is:**
   A. five times B. fifteen times
   C. two times D. eight times

xi. **At 1 atm pressure and 21 °C (room temperature) the speed of sound in air is;**
   A. 343 ms^{-1} B. 340 ms^{-1}
   C. 341 ms^{-1} D. 345 ms^{-1}

xii. **The sensation of sound persists in our brain for about**
   A. 0.001s B. 0.2s
   C. 0.1s D. 10s

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet-B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. **(6 × 3 = 18)**

i. What is the necessary condition for the production of sound?

ii. What is the effect of the medium on the speed of sound? In which medium sound travels more faster: air, solid or liquid? Justify your answer.

iii. How can you prove the mechanical nature of sound by a simple experiment?

iv. Sound is a form of wave. List at least three reasons to support the idea that sound is a wave.

v. We know that waves manifest phenomenon of reflection, diffraction and refraction. Does sound also manifest these characteristics?

vi. Calculate the intensity levels of the (a) faintest audible sound (b) rustling of leaves.

vii. What do you mean by the term intensity level of the sound? Name and define the unit of intensity level of sound.

viii. What are the units of loudness? Why do we use logarithmic scale to describe the range of the sound intensities we hear?

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. **(5 × 3 = 15)**

i. Describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound.

ii. If the pitch of sound is increased, what are the changes in the following?
   a. the frequency b. the wavelength
   c. the wave velocity d. the amplitude of the wave

iii. If we clap or speak in front of a building while standing at a particular distance, we rehear our sound after sometime. Can we explain how does this happen?

v. A normal conversation involves sound intensities of about 3.0×10^{-4} Wm^{-2}. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?

vi. At a particular temperature, the speed of sound in air is 330 ms^{-1}. If the wavelength of a note is 5 cm, calculate the frequency of the sound wave. Is this frequency lies in the audible range of the human ear?

vii. What are the uses of ultrasound in medicine?

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **($2 \times 10 = 20$)**

Q.4 a. What do you understand by the longitudinal wave? Describe the longitudinal nature of sound waves.

b. If at Anarkali bazar Lahore, the sound level is 80 dB, what will be the intensity level of sound there?

Q.5 a. On what factors does the loudness of sound depend?

b. A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5 s later. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

Q.6 a. How speed of sound varies with different mediums give relation to find the speed of sound. How can you find the speed of sound by echo method? What factors can affect the accuracy of this method?

b. A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

Solution of Guess Paper & Model Paper # 2

(Reduced Syllabus)

SECTION- A (MCQs)

i. A	ii. A	iii. B	iv. C	v. D	vi. B
vii. A	viii. A	ix. B	x. B	xi. A	xii. C

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. **($6 \times 3 = 18$)**

i. What is the necessary condition for the production of sound?

Ans: The necessary condition for the production of sound is vibration of a body.

ii. What is the effect of the medium on the speed of sound? In which medium sound travels more faster: air, solid or liquid? Justify your answer.

Ans: Effect of the medium:

Sound travels faster in those mediums that are more dense (particles are closer to each other, and can transmit their energy to the other particles more easily. Therefore sound travels faster in solids, than liquids, and then air.

The speed of sound depends on two factors: elasticity and density. The more elastic a medium, the greater the speed. The more dense the medium the slower the speed of sound. For example steel is 6000 times more dense than air but 2,000,000 times more elastic than air, so sound travels 18 times faster in steel than in air.

Example: In steel sound's velocity is about 5000 m/s, in water 1400 m/s and in air 344 m/s.

iii. How can you prove the mechanical nature of sound by a simple experiment?

Ans: Mechanical nature of sound:

Experiment:

A ringing bell is placed in a jar and air inside the jar is evacuated. Once air is removed from the jar, the sound of the ringing bell can no longer be heard. The clapper is seen striking the bell; but the sound that it produces cannot be heard because there are no particles inside of the jar to transport the disturbance through the vacuum. Sound is a mechanical wave and cannot travel through a vacuum.

iv. Sound is a form of wave. List at least three reasons to support the idea that sound is a wave.

Ans: i. Sound wave carries energy like other waves therefore sound is the form of wave.

ii. Sound wave obeys the property of reflection refraction; diffraction like other waves therefore sound is the form of wave.

iii. Sound wave obeys the property of interference like other waves therefore sound is the form of wave.

v. We know that waves manifest phenomenon of reflection, diffraction and refraction. Does sound also manifest these characteristics?

Ans: Like any wave, a sound wave doesn't just *stop* when it reaches the end of the medium or when it encounters an obstacle in its path. Rather, a sound wave will undergo certain behaviors when it encounters the end of the medium or an obstacle. Possible behaviors include reflection off the obstacle, diffraction around the obstacle, and transmission (accompanied by refraction) into the obstacle or new medium.

Therefore sound waves manifest phenomenon of reflection, diffraction and refraction.

vi. Calculate the intensity levels of the (a) faintest audible sound (b) rustling of leaves.

Solution:

(a) **Intensity level of faintest audible sound can be calculated by substituting $I = I_o = 10^{-12}$ Wm^{-2} in Eq. (11.5).**

Therefore, intensity level of faintest audible sound = $10 \log \frac{I}{I_o} = 10 \log \frac{i}{I_o}$ = 0 dB

(b) **As the intensity of the rustle of leaves is $I = 10^{-11}$ Wm^{-2}. Therefore,**
Intensity level due to rustling of leaves = $10 \log 10^{-11}/10^{-12} = 10 \log 10 = 10$ dB

vii. What do you mean by the term intensity level of the sound? Name and define the unit of intensity level of sound.

Ans: Sound Intensity Level/Acoustic Intensity Level:

Sound intensity level or acoustic intensity level is a logarithmic measure of the sound intensity, in comparison to a reference level.

The loudness *(L)* of a sound is directly proportional to the logarithm of intensity i.e.

$L \propto \log I$

$L = K \log I$ .... (i)

Where K is a constant of proportionality. Let L_o be the loudness of the faintest audible sound of intensity I_o and L be the loudness of an unknown sound of intensity I, then by Eq. (i), we can write

$L_o = K \log I_o$ .... (ii)

Subtracting Eq. (i) from Eq. (ii), we get $L - L_o = K(\log I - \log I_o) = K \log \frac{I}{I_o}$

Intensity level:

This difference, $(L - L_o)$, between the loudness L of an unknown sound and the loudness L_o is called the intensity level of the unknown sound. Therefore, the intensity level of an unknown sound is given by

Sound level = $K \log \frac{I}{I_o}$ .... (iii)

Sound level = $\log \frac{I}{I_o}$ (bel) .... (iv)

Sound level = $10 \log \frac{I}{I_o}$ (dB) .... (v)

Unit: The SI unit of intensity level or sound level is bel.

Note: bel is a very large unit of intensity level of a sound. Generally, a small unit called decibel (dB) is used. 1

Decibel: A logarithmical unit which measures the intensity or level of a signal.

Decibel scale is a logarithmic scale which is based on the multiple of 10. A Decibel is equal to the ratio of physical quantities with respect to a reference level.

viii. What are the units of loudness? Why do we use logarithmic scale to describe the range of the sound intensities we hear?

Ans: ***Bel, Sone, Phon, Decibel.***

Because the ear responds to sound pressure logarithmically, using a logarithmic scale corresponds to the way humans perceive loudness. Audio meters and sound measurement equipment are specifically designed to show audio levels in decibels. That is why we use logarithmic scale to describe the range of the sound intensities we hear.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Describe the effect of change in amplitude on loudness and the effect of change in frequency on pitch of sound.

Ans: Effect of change in amplitude on loudness:

The loudness of the sound varies directly with the amplitude of the vibrating body. The sound produced by a sitar will be loud if we pluck its wires more violently. Similarly, when we beat a drum forcefully, the amplitude of its membrane increases and we hear a loud sound.

$$Loudness \propto Amplitude\ of\ the\ vibrating\ body$$

Effect of change in frequency on pitch of sound:

Pitch depends upon the frequency. A higher pitch means a higher frequency and vice versa.

$$Pitch \propto Frequency$$

ii. If the pitch of sound is increased, what are the changes in the following?

a. the frequency **b. the wavelength**
c. the wave velocity **d. the amplitude of the wave**

Ans: a. The frequency:

If the pitch of the sound is increased its frequency is also increased. $Pitch \propto Frequency$

b. The wavelength:

If the pitch of the sound is increased its wavelength is decreased. $Pitch \propto \frac{1}{Wavelength}$

c. The wave velocity:

If the pitch of the sound is increased its wave velocity v is increased. $Pitch \propto Velocity$

d. The amplitude of the wave:

If the pitch of the sound is increased the amplitude of the wave does not change because pitch of the sound does not depend on the amplitudes.

iii. If we clap or speak in front of a building while standing at a particular distance, we rehear our sound after sometime. Can we explain how does this happen?

Ans: This is due to echo of sound. An echo (plural echoes) is a *reflection* of sound, arriving at the listener some time after the direct sound.

Explanation:

Sound is a waveform made from vibrating matter. The sound wave travels through matter—especially air—in a straight line. When the wave hits a different material, some of it is reflected, absorbed and transmitted through the material. In the case of a sound wave in air hitting a solid wall, most of the sound is reflected.

If the wall is relatively flat, perpendicular to the source of the sound, and far enough away (but not too far), then you can hear the reflected waveform or echo. If the sound comes back in about 0.1 second or longer, you can readily distinguish the echo.

iv. What is the audible frequency range for human ear? Does this range vary with the age of people? Explain.

Ans: Audible Frequency Range:

A normal human ear can hear a sound only if its frequency lies between 20Hz and 20,000 Hz. In other words, a human ear neither hears a sound of frequency less than 20 Hz nor a sound of frequency more than 20,000 Hz.

v. A normal conversation involves sound intensities of about 3.0×10^{-6} Wm^{-2}. What is the decibel level for this intensity? What is the intensity of the sound for 100 dB?

Solution: Intensity of sound = $I = 3.0\times 10^{-6} Wm^{-2}$

Here faintest sound intensity $I_o = 10^{-12} Wm^{-2}$ (1 Bell=10 dB)

Intensity level = ?

Intensity level $=10\log\frac{I}{I_o}$ dB ......(i)

Intensity level $=10\log\frac{3.0\times10^{-6}}{10^{-12}} = 10\log 3.0\times10^{6}$

We know $\log(mn) = \log m + \log n$

Intensity level $=10(\log 3 + \log 10^{6}) = 10(0.48 + 6\times \log 10) = 10(0.48 + 6\times 1) = 64.8$ dB

(ii) *When Sound level = 100 dB*

Intensity of sound = I = ? ; Sound level $=10\log\frac{I}{I_o}$ dB .....(i)

$100\text{ dB} = 10\log\frac{I}{10^{-12}}$ dB ; $10 = \log\frac{I}{10^{-12}}$; $10 = \log I - \log 10^{-12}$

$10 = \log I + 12\log 10$; $10 = \log I + 12(1)$; $10 - 12 = \log I$; $\text{Log } I = -2$

Taking antilog on both sides

$I = \text{antilog}(-2) \Rightarrow I = 0.01\ Wm^{-2}$

vi. At a particular temperature, the speed of sound in air is 330 ms^{-1}. If the wavelength of a note is 5 cm, calculate the frequency of the sound wave. Is this frequency lies in the audible range of the human ear?

Solution: The speed of sound = $v = 330\ ms^{-1}$; Wavelength = $\lambda = 5\text{ cm} = \frac{5}{100} = 0.05$ m

Frequency = f =? ; $f = \frac{v}{\lambda} = \frac{330}{0.5} = 6.6\times10^{3}$ Hz

Yes this frequency lies audible range of human ear. (20 Hz to 20,000 Hz)

vii. What are the uses of ultrasound in medicine?

Ans: Uses of ultrasound in medicine:

- In medical field, ultrasonic waves are used to diagnose and treat different ailments. For diagnosis of different diseases, ultrasonic waves are made to enter the human body through transmitters. These waves are reflected differently by different organs, tissues or tumors etc. The reflected waves are then amplified to form an image of the internal organs of the body on the screen. Such an image helps in detecting the defects in these organs.
- Powerful ultrasound is now being used to remove blood clots formed in the arteries.
- Ultrasound can also be used to get the pictures of thyroid gland for diagnosis purposes.
- Germs and bacteria in liquids can also be destroyed by using high intensity ultrasonic waves.

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. What do you understand by the longitudinal wave? Describe the longitudinal nature of sound waves.

Ans: Longitudinal waves:

In longitudinal waves the particles of the medium move back and forth along the direction of propagation of wave.

Longitudinal Nature of Sound Waves:

(*a*). When the right prong of tuning fork moves from mean position O to B (*b*), it exerts some pressure on the adjacent layer of air molecules and produces a compression.

Vibrations of tuning fork after striking with a rubber hammer

This compressed air layer in turn compresses the layer next to it and so on. A moment later, the prong begins to move from B towards A (*c*). Now the pressure in the adjacent layer decreases and a rarefaction is produced. This rarefaction is transferred to the air layer next to it and so on. As the tuning fork moves back and forth rapidly, a series of compressions and rarefactions are created in the air. In this way, sound wave propagates through the air.

Conclusion:

As in the direction of propagation of sound wave is along the direction of oscillating air molecules. This shows the longitudinal nature of sound waves. Distance between two consecutive compressions or rarefactions is the wavelength of sound wave.

b. If at Anarkali bazar Lahore, the sound level is 80 dB, what will be the intensity level of sound there?

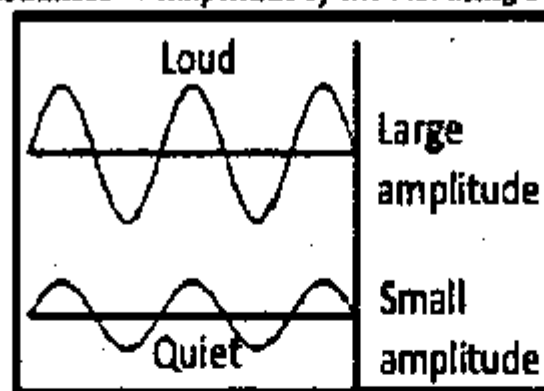
Solution: **See Q2. (v), Past FBISE Paper (2018), Page # 121.**

Q.5 a. On what factors does the loudness of sound depend?

Ans: Loudness of a sound depends upon a number of factors.

(a) Amplitude of the vibrating body:

The loudness of the sound varies directly with the amplitude of the vibrating body. The sound produced by a sitar will be loud if we pluck its wires more violently. Similarly, when we beat a drum forcefully, the amplitude of its membrane increases and we hear a loud sound.

$$Loudness \propto Amplitude\ of\ the\ vibrating\ body$$

Variation of loudness with amplitude

(b) Area of the vibrating body:

The loudness of sound also depends upon the area of the vibrating body. For example, sound produced by a large drum is louder than that by small one because of its large vibrating area. If we strike a tuning fork on a rubber pad, a feeble sound will be heard. But if the vibrating tuning fork is placed vertically on the surface of a bench, we will hear a louder sound. From this we can conclude that the loudness increases with the area of the vibrating body and vice versa.

$$Loudness \propto Area\ of\ the\ vibrating\ body$$

(c) Distance from the vibrating body:

Loudness of sound also depends upon the distance of the vibrating body from the listener. It is caused by the decrease in amplitude due to increase in distance.

Note:

1. Loudness also depends upon the physical condition of the ears of the listener. A sound appears louder to a person with sensitive ears than to a man with defective ears.
2. However, there is a characteristic of sound which does not depend upon the sensitivity of the ear of the listener and it is called intensity of sound.

b. A marine survey ship sends a sound wave straight to the sea bed. It receives an echo 1.5 s later. The speed of sound in sea water is 1500 ms^{-1}. Find the depth of the sea at this position.

Solution: Speed of sound = v = 1500 ms^{-1} ; Time = t = 1.5 s ; Depth = d = ?

$d = vt$ ....(i)

For echo sound waves travel the total distance d + d = 2d

Put in (i) $2d = vt$

$$2d = (1500) \times (1.5) \Rightarrow d = \frac{2250}{2} \Rightarrow d = 1125\ m$$

Q.6 a. How speed of sound varies with different mediums give relation to find the speed of sound. How can you find the speed of sound by echo method? What factors can affect the accuracy of this method?

Ans: Speed of Sound:

In general, the speed of sound in a liquid is *five times* that in gases; the speed of sound in solid is about *fifteen times* that in gases. The speed of sound in air is affected by changes in some physical conditions such as temperature, pressure and humidity etc.

Speed of sound in air:

The speed of sound in air is 343 ms^{-1} at one atmosphere of pressure and room temperature (21°C).
The speed varies with temperature and humidity. The speed of sound in solids and liquids is faster than in air.

Formula to find the speed of sound:

Following relation can be used to find the speed of sound.

$$v = f\lambda$$

Where v is the speed, f is the frequency and λ is the wavelength of sound wave.

Measuring Speed of Sound by Echo Method:

Apparatus: Measuring tape, stopwatch, flat wall that can produce a good echo.

Procedure:

i. Use the tape to measure a distance of 50 metres from the wall.
ii. Now clap your hands in front of the wall at a distance of 50 metres and check if you can clearly hear an echo from the well. Make sure the echo is not coming from any other wall in the area. The time taken by the sound to travel 100 metres is the time difference between the clap and the echo.
iii. Now restart the clapping and start the stopwatch at the first clap. Count the number of claps, and stop the clapping and the stopwatch when you hear the echo of the 10th clap (say).
iv. Now find the average time for 10 claps. After calculating the time interval t between claps and using the formula $s = vt$, we can calculate the speed of the sound.

b. A doctor counts 72 heartbeats in 1 min. Calculate the frequency and period of the heartbeats.

Solution: Number of heartbeats = n = 72
Time = t = 1 min.= 60 sec.
Frequency = f = ?
Time period = T = ?

$$f = \frac{number\ of\ heartbeats}{time} = \frac{72}{60} = 1.2\ Hz$$

Since, $T = \frac{1}{f} = \frac{1}{1.2} = 0.83$ sec.

Included Tables: 11.1 and 11.2

Table 11.1

Source of Sound	Intensity (Wm^{-2})	Intensity level (dB)
Nearby jet airplane	10^{3}	150
Jackhammer / Fast Train	10^{1}	130
Siren	10^{0}	120
Lawn Mover	10^{-2}	100
Vacuum Cleaner	10^{-5}	70
Mosquito buzzing	10^{-8}	40
Whisper	10^{-9}	30
Resulting of leaves	10^{-11}	10
Faintest audible sound i.e. Threshold	10^{-12}	0

Table 11.2

Speed of sound in various media	
Medium	**Speed (ms^{-1})**
Gases	
Air (0°C)	331
Air (25°C)	346
Air (100°C)	386
Hydrogen (0°C)	1290
Oxygen (0°C)	317
Helium (0°C)	972
Liquids at 25°C	
Distilled water	1498
Sea water	1531
Solids 25°C	
Woods	2000
Aluminum	6420
Brass	4700
Nickel	6040
Iron	5950
Steel	5960
Flint Glass	3980

IMPORTANT QUESTIONS & ANSWERS

Q1. A student clapped his hands near a cliff and heard the echo after 5s. What is the distance of the cliff from the student if the speed of the sound, v is taken as 346 ms⁻¹?

Solution: Time = t = 5 sec. ; Speed of sound = v = 346 ms^{-1} ; Distance = d = ?

Since, d = vt .... (i)

For echo sound waves travel the total distance d + d = 2 d

Put in (i) $2d = 346 \times 5 \Rightarrow 2d = 1730 \Rightarrow d = \frac{1730}{2} \Rightarrow d = 865\text{ m}$

Q2. A ship sends out ultrasound that returns from the seabed and is detected after 3.42s. If the speed of ultrasound through seawater is 1531 ms⁻¹, what is the distance of the seabed from the ship?

Solution: Time = t = 3.42 Sec. ; Speed of sound = v = 1531 ms^{-1}

Distance = d = ? ; Since, d = vt ......(i)

Ultra – sound travels the total distance d + d = 2 d

Put in (i) we get: $2d = (1531) \times (3.42) \Rightarrow d = \frac{5236.02}{2} \Rightarrow d = 2618\text{ m}$

Q3. Why two tin cans with a string stretched between them could be better way to communicate than merely shouting through the air?

Ans: When two tin cans are attached with a stretched string then the string becomes a medium that transmit sound wave from one can to the other. String is a solid and it makes a batter medium of transmitting sound wave rather than air. When we shout in air then air carries sound with low speed than a stretched string.

Q4. We can recognize persons speaking with the same loudness from their voice. How is this possible?

Ans: We can recognize persons speaking with the same loudness from their voice because their quality of sound is different. Quality of sound is the characteristic by which we can distinguish between two sounds of same loudness and pitch. The waveforms of sound produced by persons are different. So their quality is different and they can be distinguished from each other.

Q5. You can listen to your friend round a corner, but you cannot watch him/her. Why?

Ans: Wavelength of sound waves is large and is comparable with the size of buildings and corners. So sound of our friend can be diffracted and easily heard by us. However, light rays have small wavelength and cannot be diffracted, which makes it impossible for us to see our friend round a corner.

Q6. Why must the volume of a stereo in a room with wall-to-wall carpet be tuned higher than in a room with a wooden floor?

Ans: In carpeted floor rooms, the volume of stereo will be higher due to less amount of reverberations. Volume of a stereo in a room with wall to wall carpet must be tuned higher than in a room with a wooden floor because reflection of sound (reverberations/after effects) is more prominent if the surface is smooth (carpeted), and less if the surface is irregular (wooden floor).

Q7. A student says that the two terms *speed* and *frequency* of the wave refer to the same thing. What is your response?

Ans: No, the statement of student is not correct. Speed is the distance traveled by the wave in unit time (one second). Frequency is the number of vibrations in the medium in unit time (one second). Speed of a wave is how fast the wave is moving in a medium while the frequency of wave is the number of cycle per unit of time. So these two things are not same. Also frequency does not depend on the nature of medium, but speed of wave is different in different media.

Q9. Will two separate 50dB sounds together constitute a100dB sound? Explain

Ans: No, two separate 50dB sounds together do not constitute a 100dB sound because dB is an exponential scale (logarithmic scale). Each ten dB increase in sound makes the sound ten times louder.
An increase of 50dB makes the sound 10^4 times louder.
Hence it will not make 100dB but twice as loud is an increase of 10Log (2) = 3.01dB. So 53.01dB is twice as loud as 50dB.

Q10. Why ultrasound is useful in medical field?

Ans: Ultrasound wavelength are shorter as compared to normal sound waves. Because of this the ultrasound waves are reflected back by obstacles in their path rather than bending round them and move forward. This quality of ultrasound makes it useful in many different fields including medical field.
The ultrasound techniques score over the x-ray techniques for obtaining images of internal organ in that these are safer.
Active use of ultrasound in medical field includes destruction of brain tumors and kidney stones.

Q11. Define ultrasound or ultrasonic.

Ans: Ultrasound:
Sounds of frequency higher than 20,000 Hz which are inaudible to normal human ear are called ultrasound or ultrasonic.

Q12. What is the difference between the loudness and intensity of sound? Derive the relationship between the two.

Ans: Sound intensity is the amount of energy carried by sound whereas loudness is a measurement of the audible sound.

Loudness vs Sound Intensity:

- Sound intensity is a property of the sound source but loudness depends on the sound source, the medium and the receiver; as well.
- Sound intensity holds a small significance in problems involving human hearing system, but loudness is a very important property to consider in such problems.
- Sound intensity is measured in Watt per square meter whereas loudness is measured in Sones.

Relationship between the loudness and intensity of sound:

The *loudness* (L) of a sound is directly proportional to the logarithm of *Intensity* (I) i.e.

$L \propto \log I$

$L = K \log I$ .... (i)

Q13. The highest frequency sound humans can hear is about 20,000 Hz. What is the wavelength of sound in air at this frequency at a temperature of 20°C? What is the wavelength of the lowest sounds we can hear of about 20 Hz? Assume the speed of sound in air at 20°C is 343 ms⁻¹.

Solution: Highest frequency = $f_m = 20,000$ Hz ; Lowest frequency = $f_L = 20$ Hz
Speed of sound = v = 343 ms^{-1} ; Wavelength of highest sound = λ_L = ?
Wavelength of minimum sound = λ_m = ?

Since, $= f\lambda = v$ .... (i) Since, $\lambda_L = \frac{v}{f_m}$

$$\lambda_L = \frac{343}{20000} = 0.017 = 1.7 \times 10^{-3} \text{ m}$$

Now, $\lambda_m = \frac{v}{f_L} = \frac{343}{20} = 17.2$ m

Q14. Calculate the frequency of a sound wave of speed 340 ms^{-1} and wavelength 0.5 m.

Solution: Given that; Speed of waves = v = 340 ms^{-1}
Wavelength = λ = 0.5 m
Frequency = f = ?

Using the formula = $f = \frac{v}{}$

UNIT 12: GEOMETRICAL OPTICS

All theory topics from 12.1 - 12.10

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 3 BASED ON UNIT # 12 (Reduced Syllabus) GEOMETRICAL OPTICS

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. Which of the following quantities is not changed during refraction of light?
A. its direction B. its speed
C. its frequency D. its wavelength

ii. A converging mirror with a radius of 20 cm creates a real image 30 cm from the mirror. What is the object distance?
A. 5.0cm B. 7.5 cm C. 15 cm D. 20 cm

iii. An object is placed at the centre of curvature of a concave mirror. The image produced by the mirror is located
A. out beyond the centre of curvature. B. at the centre of curvature.
C. between the centre of curvature and the focal point D. at the focal point

iv. An object is 14 cm in front of a convex mirror. The image is 5.8 cm behind the mirror. What is the focal length of the mirror?
A. 4.1cm B. 8.2 cm C. 9.9 cm D. 20 cm

v. The index of refraction depends on
A. the focal length B. the speed of light
C. the image distance D. the object distance

vi. Which type of image is formed by a concave lens on a screen?
A. inverted and real B. inverted and virtual
C. upright and real D. upright and virtual

vii. If the object is towards the right side of the lens, the object distance will be
A. zero B. constant C. positive D. negative

viii. A convex mirror is used to reflect light from an object placed 30 cm in front of the mirror. If the focal length of the mirror is 20 cm then the location of the image should be
A. −27 cm B. −37 cm C. −29 cm D. −47 cm

ix. If a ray of light in glass is incident on an air surface at an angle greater than the critical angle, the ray will
- A. refract only
- B. reflect only
- C. partially refract and partially reflect
- D. diffract only

x. The critical angle for a beam of light passing from water into air is 48.8 degrees. This means that all light rays with an angle of incidence greater than this angle will be
- A. absorbed
- B. totally reflected.
- C. partially reflected and partially transmitted
- D. totally transmitted

xi. The image with convex lens is formed at 2F real, inverted, the same size as the object at?
- A. 2F
- B. Between F and 2F
- C. smaller than object
- D. all the given answers

xii. If the object is towards the right side of the lens, it is said to be
- A. real object
- B. virtual object
- C. small object
- D. thick object

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet-B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. What do you understand by reflection of light? Draw a diagram to illustrate reflection at a plane surface.

ii. An object 30.0 cm tall is located 10.5 cm from a concave mirror with focal length 16.0cm. (a) Where is the image located? (b) How high is it?

iii. State laws of reflection. Describe how they can be verified graphically.

iv. Define refraction of light. Describe the passage of light through parallel-sided transparent material

v. An object 10 cm high is placed at a distance of 20 cm from a concave lens of focal length 15 cm. Calculate the position and size of the image. Also, state the nature of the image.

vi. What is meant by refractive index of a material? How would you determine the refractive index of a rectangular glass slab?

vii. State the laws of refraction of light and show how they may be verified using Rectangular glass slab and pins.

viii. What is meant by the term total internal reflection?

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. State the conditions for total internal reflection.

ii. What is critical angle? Derive a relationship between the critical angle and the refractive index of a substance.

iii. Define the following terms applied to a lens:
(i) Principal axis (ii) Optical centre (iii) Focal length

iv. What is meant by the principal focus of a (a) convex lens (b) a concave lens? Illustrate your answer with ray diagrams.

v. Describe how light is refracted through convex lens.

vi. Define the terms resolving power and magnifying power.

vii. A coin is placed at a focal point of a converging lens is an image formed? What is its nature?

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. What are optical fibres? Describe how total internal reflection is used in light propagating through optical fibres.

b. An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20.0 cm from the mirror. What is the focal length of the mirror?

Q.5 a. Explain image formation with ray diagrams for objects placed at different positions from a convex lens.

b. The power of a convex lens is 5D. At what distance the object should be placed from the lens so that its real and 2 times larger image is formed.

Q.6 a. How does a converging lens form a virtual image of a real object? How does a diverging lens can form a real image of a real object?

b. Find the focal length of a mirror that forms an image 5.66 cm behind a mirror of an object placed at 34.4 cm in front of the mirror.

Solution of Guess Paper & Model Paper # 3
(Reduced Syllabus)

SECTION- A (MCQs)

i. C	ii. C	iii. B	iv. C	v. B	vi. D
vii. D	viii. A	ix. B	x. B	xi. A	xii. B

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. **(6 × 3 = 18)**

i. **What do you understand by reflection of light? Draw a diagram to illustrate reflection at a plane surface.**

Ans: Reflection of Light:

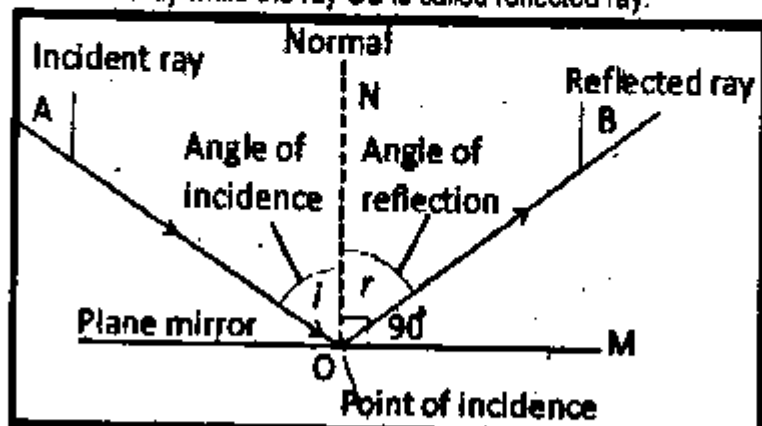
When light travelling in a certain medium falls on the surface of another medium, a part of it turns back in the same medium. This is called reflection of light.

Laws of Reflection:

(i) *The incident ray, the normal, and the reflected ray at the point of incidence all lie in the same plane.*

(ii) *The angle of incidence is equal to the angle of reflection i.e. $\angle i = \angle r$.*

Illustration of reflection of light:

When a ray of light from air along the path AO falls on a plane mirror M, it is reflected along the path OB. The ray AO is called incident ray while the ray OB is called reflected ray.

ii. An object 30.0 cm tall is located 10.5 cm from a concave mirror with focal length 16.0cm. (a) Where is the image located? (b) How high is it?

Solution: $Object\ height = O = 30.0\ cm$; $Object\ distance = p = 10.5\ cm$
$Focal\ length = f = 16.0\ cm$; $Image\ distance = q = ?$
$Image\ height = I = ?$

Mirror equation is: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{q} = \frac{1}{f} - \frac{1}{p} \Rightarrow \frac{1}{q} = \frac{1}{16} - \frac{1}{10.5} \Rightarrow \frac{1}{q} = \frac{10.5 - 16}{16 \times 10.5}$

$$\frac{1}{q} = \frac{-5.5}{168} \Rightarrow q = -\frac{168}{5.5} \Rightarrow q = -30.54\ \text{cm}$$

The negative sign of q shows that the image is virtual and forms behind the mirror.

$$\textbf{Magnification} = \frac{I}{O} = \frac{q}{p} \Rightarrow I = \frac{q}{p} \times O \Rightarrow I = \frac{30.54}{10.5} \times 30.0 = \frac{916.2}{10.5} = 87.26\ \text{cm}$$

iii. State laws of reflection. Describe how they can be verified graphically.

Ans: Laws of Reflection:

(i) *The incident ray, the normal, and the reflected ray at the point of incidence all lie in the same plane.*
(ii) *The angle of incidence is equal to the angle of reflection i.e. $\angle i = \angle r$.*

iv. Define refraction of light. Describe the passage of light through parallel-sided transparent material

Ans: Refraction of Light:

The bending of light as it passes from one transparent medium into another is called ***refraction.***

In mirrors, image formation takes place through reflection of light while in lenses image is formed through refraction of light.

Example:

If we dip one end of a pencil or some other object into water at an angle to the surface, the submerged part looks bent. Its image is displaced because the light coming from the underwater portion of the object changes direction as it leaves the water.

This process of bending of light as it passes from air into glass and vice versa is called refraction of light.

v. An object 10 cm high is placed at a distance of 20 cm from a concave lens of focal length 15 cm. Calculate the position and size of the image. Also, state the nature of the image.

Solution:

Size of object = h_o = 10 cm; Distance of object = p = 20 cm ; Focal length = f = -15 cm (for concave lens)

(a) Position of image = q = ? **(b)** Size of image = h_i = ? **(c)** Nature of image = ?

(a) Using the formula: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{q} = \frac{1}{f} - \frac{1}{p} \Rightarrow \frac{1}{q} = \frac{1}{-15} - \frac{1}{20}$

$$\frac{1}{q} = \frac{-20-15}{15 \times 20} \Rightarrow \frac{1}{q} = \frac{-35}{300} \Rightarrow q = \frac{-300}{35} = -8.57\ \text{cm}$$

(b) $\frac{h_i}{h_o} = \frac{q}{p} \Rightarrow h_i = \frac{q}{p} \times h_o \Rightarrow h_i = \frac{-8.57}{20} \times 10 = 4.28\ \text{cm}$

(c) Nature of Image:

Since the lens in concave and object is larger in size than the size of the image, therefore the image is virtual, erect and diminished.

vi. What is meant by refractive index of a material? How would you determine the refractive index of a rectangular glass slab?

Ans: Refractive Index or index of refraction:

The refractive index n of a medium is the ratio of the speed c of light in a vacuum to the speed v of light in the medium:

Refractive Index = $\frac{Speed\ of\ light\ in\ vaccuum}{speed\ in\ light\ in\ medium}$ or $n = \frac{c}{v}$

Refractive Index of a rectangular glass slab:

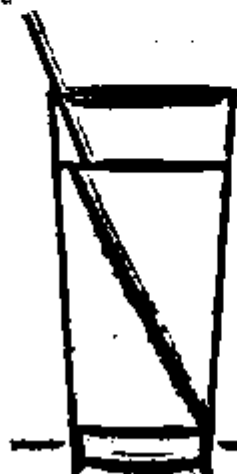
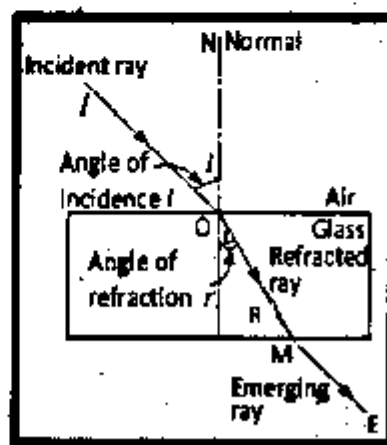
vii. State the laws of refraction of light and show how they may be verified using Rectangular glass slab and pins.

Ans: Laws of Refraction:

(I) The incident ray, the refracted ray, and the normal at the point of incidence all lie in the same plan.

(II) The ratio of the *sine* of the angle of incidence i to the *sine* of the angle of refraction r is always equal to a constant i.e. $\sin i/\sin r$ = constant

Passage of light through parallel-sided transparent material:

Refraction of light can be explained with the help of Fig. A ray of light IO travelling from air falls on the surface of a glass block.

Bending of pencil in water due to refraction

Refraction of light by a glass block

At the air-glass interface, the ray of light IO changes direction and bends towards the normal and travels along the path OR inside the glass block.

We see that the incident ray, the refracted ray and the normal, all lie on the same plane at point O. (So first law is verified).

We will see that in all the three readings the value of the ratio $\frac{\sin i}{\sin r}$ will became constant.

(So that second law is also verified).

viii. What is meant by the term total internal reflection?

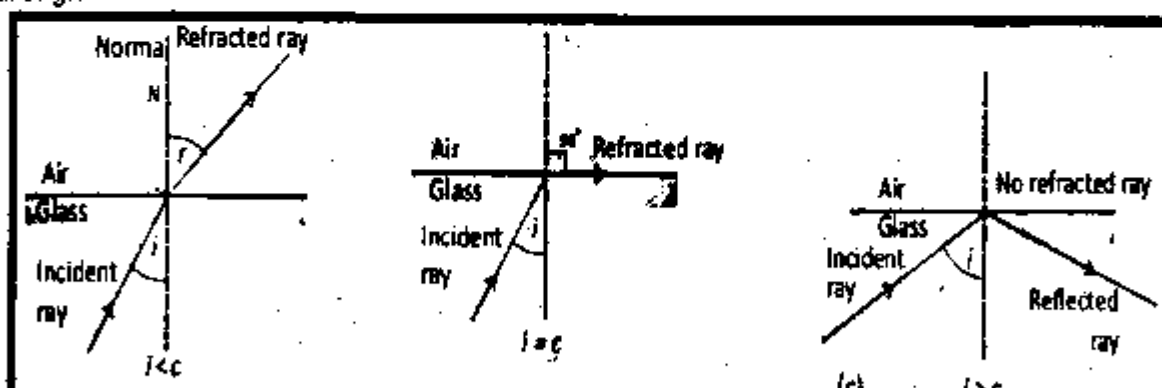
Ans: Total Internal Reflection:

The angle of incidence for which the angle of refraction becomes 90° is called critical angle. When the angle of incidence becomes larger than the critical angle, no refraction occurs. The entire light is reflected back into the denser medium. This is known as total internal reflection of light.

Explanation:

When a ray of light enters from a denser medium to a rarer medium it bends away from the normal. If the angle of incidence increases the angle of refraction also increases. For a particular value of the angle of incidence the angle of refraction becomes 90°.

Critical Angle:

The angle of incidence that causes the refracted ray in the rarer medium to bend through 90° is called critical angle.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. State the conditions for total internal reflection.

Ans: Condition for total internal reflection:

Conditions essential for the total internal reflection are.

I- The ray of light should travel from a denser medium to a rarer medium.

II- The angle of incidence should be greater than the critical angle.

ii. What is critical angle? Derive a relationship between the critical angle and the refractive index of a substance.

Ans: Critical angle:

When light enters from a denser medium to a rarer medium then the angle of incidence whose angle of refraction becomes 90° is called critical angle. It is denoted by C.

Relationship between the critical angle and the refractive index:

According to Snell's law $\frac{\sin i}{\sin r} = \frac{\sin \hat{C}}{\sin 90^0} = \frac{1}{n} \Rightarrow \sin \hat{C} = \frac{1}{n}$ or $n = \frac{1}{\sin \hat{C}}$

Where i = angle of incidence ; r = angle of refraction ; C = Critical angle ; n = Refractive index

iii. Define the following terms applied to a lens:

(i) Principal axis (ii) Optical centre (iii) Focal length

Ans: i. Principal Axis:

Each of the two surfaces of a spherical lens is a section of a sphere. The line passing through the two centres of curvatures of the lens is called principal axis.

ii. Optical Centre: A point on the principal axis at the centre of lens is called optical centre.

iii. Focal length: This is the distance between the optical centre and the principal focus.

iv. What is meant by the principal focus of a (a) convex lens (b) a concave lens? Illustrate your answer with ray diagrams.

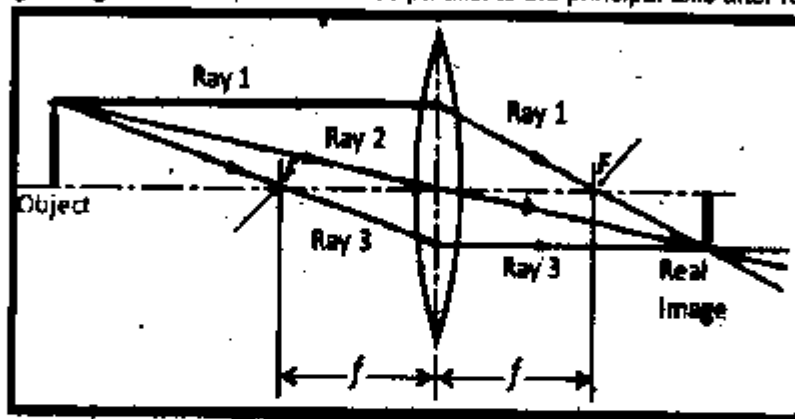
Ans: See Q2. (iii), Past FBISE Paper (2019), Page # 126.

v. Describe how light is refracted through convex lens.

Ans: Refraction of light through convex lens:

Formation of images in convex lens:

Image formation in convex lens can be explained with the help of three principal rays.

1. The ray parallel to the principal axis passes through the focal point after refraction by the lens.
2. The ray passing through the optical centre passes straight through the lens and passes undeviated.
3. The ray passing through the focal point becomes parallel to the principal axis after refraction by the lens.

Convex Lens

vi. Define the terms resolving power and magnifying power.

Ans: Resolving Power:

The resolving power of an instrument is its ability to distinguish between two closely placed objects or point sources.

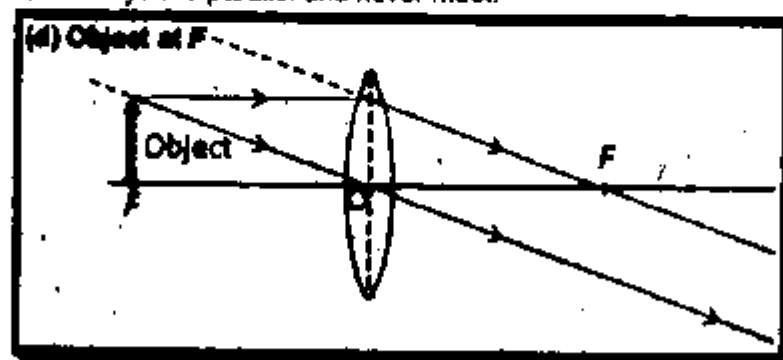
Function of resolving power:

For example, we use high resolving power microscope to see tiny organisms and telescope to view distant stars.

Magnifying power:

The magnifying power is defined as "the ratio of the angle subtended by the image as seen through the optical device to that subtended by the object at the unaided eye".

vii. A coin is placed at a focal point of a converging lens is an image formed? What is its nature?

Ans: When a coin is placed at a focal point (F) of a converging lens (Convex lens) no image is formed because the refracted rays are parallel and never meet.

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. What are optical fibres? Describe how total internal reflection is used in light propagating through optical fibres.

Ans: See Q3., Past FBISE Paper (2019), Page # 130.

b. An object and its image in a concave mirror are of the same height, yet inverted, when the object is 20.0 cm from the mirror. What is the focal length of the mirror?

Solution: Given that

Object height = Image height $\Rightarrow O = I$; Object distance $p = 20.0$ cm

Focal length $f = ?$ $Magnification = \frac{I}{O} = \frac{q}{p}$; Given that $I = O$

$$\frac{O}{O} = \frac{q}{p} \Rightarrow \frac{q}{p} = 1 \Rightarrow q = p \ldots\ldots\ldots(i)$$

Mirror equation is: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \Rightarrow \frac{1}{f} = \frac{1}{p} + \frac{1}{p}$; $(\because q = p)$

$$\frac{1}{f} = \frac{1+1}{p} \Rightarrow \frac{1}{f} = \frac{2}{p} \Rightarrow f = \frac{p}{2} \Rightarrow f = \frac{20}{2} \Rightarrow f = 10\,cm$$

Q.5 a. Explain image formation with ray diagrams for objects placed at different positions from a convex lens.

Ans: See Q3. (a), Past FBISE Paper (2014) Page # 95.

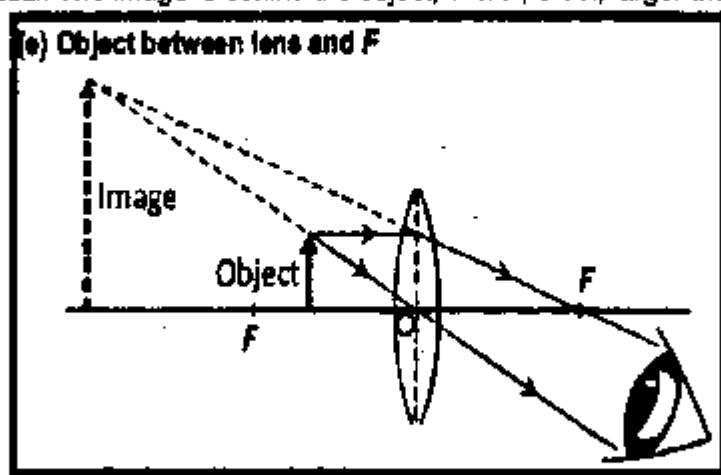
b. The power of a convex lens is 5D. At what distance the object should be placed from the lens so that its real and 2 times larger image is formed.

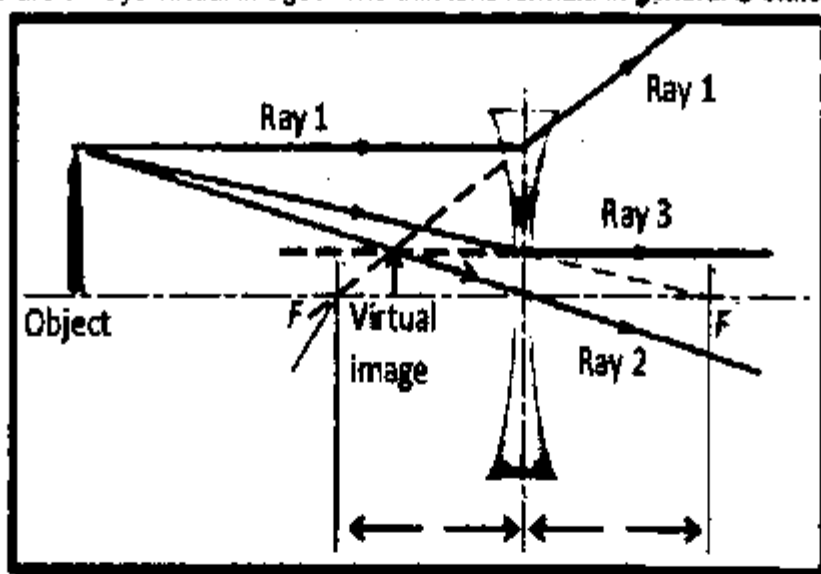
Solution: Power of a lens = p = 5 D (dipoter) ; Size of the image = q = 2p

Distance of Object = p = ? ; Since, $p = \frac{1}{f(m)}$

$$f = \frac{1}{p} \Rightarrow f = \frac{1}{5} \Rightarrow f = 0.2\text{ m} = 0.2 \times 100\,cm = 20\text{ cm}$$

Q.6 a. How does a converging lens form a virtual image of a real object? How does a diverging lens can form a real image of a real object?

Ans: Case 1: When object is placed between Principal focus (F) and optical center O then image formed will be virtual. The image is behind the object, virtual, erect, larger than the object.

Case 2:

Because the rays always diverged by a concave lens, the emerging rays do not actually intersect. But they deem (suppose) to intersect on the incidence side by tracing backwards the emerging rays. Hence concave lens images are always virtual images. The thin lens formula in general is stated as,

Concave Lens

Therefore it is not possible for a diverging or concave lens to from a real image of real object.

b. Find the focal length of a mirror that forms an image 5.66 cm behind a mirror of an object placed at 34.4 cm in front of the mirror.

Solution:

Object distance= $p = 34.4$ cm

$Image\ distance = q = -5.66\ cm$

q will be negative because image is virtual and behind the mirror.

Focal length = f = ?

Mirror equation: $\frac{1}{f} = \frac{1}{p} + \frac{1}{q} \implies \frac{1}{f} = \frac{1}{34.4} + \frac{1}{-5.66} \implies \frac{1}{f} = \frac{1}{34.4} - \frac{1}{5.66}$

$\frac{1}{f} = \frac{5.66 - 34.4}{34.4 \times 5.66} \implies \frac{1}{f} = -\frac{28.74}{194.7}$

$f = -\frac{194.7}{28.74} \implies f = -6.77\ cm$

IMPORTANT QUESTIONS & ANSWERS

Q1. An object 10.0 cm in front of a convex mirror forms an image 5.0 cm behind the mirror. What is the focal length of the mirror?

Solution: Object distance p= 10.0 cm ; Image distance q= – 5.0 cm

Since image is virtual, behind the mirror, so q taken as negative. ; Find focal length f = ?

mirror equation is: $\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{f}=\frac{1}{10}+\frac{1}{-5}$

$$\frac{1}{f}=\frac{1}{10}-\frac{1}{5} \Rightarrow \frac{1}{f}=\frac{1-2}{10} \Rightarrow f=-10\,cm$$

Since focal length is negative so mirror is convex.

Q2. An image of a statue appears to be 11.5 cm behind a convex mirror with focal length 13.5 cm. Find the distance from the statue to the mirror.

Solution: As focal length is negative for convex mirror therefore

Focal length f = -13.5 cm ; Image distance q = -11.5 cm ; Object distance p = ?

mirror equation is: $\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{p}=\frac{1}{f}-\frac{1}{q} \Rightarrow \frac{1}{p}=\frac{1}{-13.5}+\frac{1}{11.5}$

$$\frac{1}{p}=-\frac{1}{13.5}+\frac{1}{11.5}=\frac{-11.5+13.5}{13.5\times 11.5} \Rightarrow p=-\frac{155.25}{25}=-\frac{155.25}{25}=-6.2\text{ cm}$$

Q3. An image is produced by a concave mirror of focal length 8.70 cm. The object is 13.2 cm tall and at a distance 19.3 cm from the mirror, (a) Find the location and height of the image, (b) Find the height of the image produced by the mirror if the object is twice as far from the mirror.

Solution: *Focal length* $= f = 8.70\,cm$; *Object height* $= h_o = 13.2\,cm$ *Object distance* $= p = 19.3\,cm$

(a) (i) Location of image = q = ? (ii) *height of image* $= h_i = ?$

Since, $\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{q}=\frac{1}{f}-\frac{1}{p} \Rightarrow \frac{1}{q}=\frac{1}{8.7}-\frac{1}{19.3}$

$$\frac{1}{q}=\frac{19.3-8.7}{8.7\times 19.3} \Rightarrow q=\frac{10.6}{167.9} \Rightarrow q=\frac{167.91}{10.6}=15.84\,cm$$

(ii) *height of image* $= h_i$

Since, $\frac{h_i}{h_o}=\frac{q}{p} \Rightarrow h_i=\frac{q}{p}\times h_o$

$$h_i=\frac{15.84}{19.3}\times 13.2 \Rightarrow h_i=\frac{208.56}{19.3} \Rightarrow h_i=10.83\,cm$$

(b) When the object is twice as far from the mirror, then $p = 19.3\,cm \times 2 = 38.6\,cm$

$$h_i=\frac{q}{p}\times h_o \Rightarrow h_i=\frac{15.84}{38.6}\times 13.2 \Rightarrow h_i=\frac{209.09}{38.6}=5.42\,cm$$

Q4. Nabeela uses a concave mirror when applying makeup. The mirror has a radius of curvature of 38.0 cm. (a) What is the focal length of the mirror? (b) Nabeela is located 50 cm from the mirror. Where will her image appear? (c) Will the image be upright or inverted?

Solution: Radius of curvature R = 38.0 cm ; Distance of object = p = 50 cm

(a) Focal length = f = ? **(b)** Distance of image = q = ? **(c)** Nature of image = ?

(a) Focal length $f=\frac{R}{2}=\frac{38}{2}=19.0$ cm ; **(b)** Distance of image = q = 50 cm

We know the mirror equation is: $\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{q}=\frac{1}{f}-\frac{1}{p}$

$$\frac{1}{q}=\frac{1}{19}-\frac{1}{50}=\frac{50-19}{19\times 50} \Rightarrow q=\frac{950}{31} \Rightarrow q=30.64\ cm$$

(c) **Nature of image:** Since q is positive so image will be upright.

Q5. An object 4 cm high is placed at a distance of 12 cm from a convex lens of focal length 8cm. Calculate the position and size of the image also state the nature of the image.

Solution:

Height of object = h_o = 4 cm ; Distance of object = p = 12 cm; Focal length = f = 8 cm

(a) Position of image = q =? (b) Size of image = h_i =? (c) Nature of image = ?

(a) Using the formula: $\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{q}=\frac{1}{f}-\frac{1}{p} \Rightarrow \frac{1}{q}=\frac{1}{8}-\frac{1}{12}$

$$\frac{1}{q}=\frac{12-8}{8\times 12} \Rightarrow \frac{1}{q}=\frac{4}{96} \Rightarrow q=\frac{96}{4}=24\text{ cm}$$

(b) $$\frac{h_i}{h_o}=\frac{q}{p} \Rightarrow h_i=\frac{q}{p}\times h_o=\frac{24}{12}\times 4=8\text{ cm}$$

(c) **Nature of image:**

Since the lens in convex and size of image is larger than the size of the object, therefore image formed is real, inverted and magnified.

Q6. A convex lens of focal length 6 cm is to be used to form a virtual image three times the size of the object. Where the lens must be placed?

Solution: Focal length = f = 6 cm ; Distance of object = q = $-3p$ (for virtual image); Distance of object = p = ?

$$\frac{1}{f}=\frac{1}{p}+\frac{1}{q} \Rightarrow \frac{1}{6}=\frac{1}{p}-\frac{1}{3p} \Rightarrow \frac{1}{6}=\frac{3-1}{3p} \Rightarrow \frac{1}{6}=\frac{2}{3p} \Rightarrow 3p=12 \Rightarrow p=\frac{12}{3}=4\ cm$$

Q7. A ray of light from air is incident on a liquid surface at an angle of incidence 35°. Calculate the angle of refraction if the refractive index of the liquid is 1.25. also calculate the critical angle between the liquid air inter-face.

Solution: Angle of incident = $i = 35^\circ$; Refractive index = n = 1.25

(i) Angle of refraction = r = ? ; Critical angle = ?

(i) According to Snell's law,

$$n=\frac{\sin i}{\sin r} \Rightarrow \sin r=\frac{\sin i}{n} \Rightarrow \sin r=\frac{\sin 35^\circ}{1.25}=\frac{0.57}{1.25}=0.458 \Rightarrow r=\sin^{-1}(0.458) \Rightarrow r=27.13^\circ$$

(ii) For critical angle,

$$\sin C=\frac{1}{n} \Rightarrow C=\sin^{-1}\left(\frac{1}{n}\right) \Rightarrow C=\sin^{-1}\left(\frac{1}{1.25}\right) \Rightarrow C=\sin^{-1}(0.8) \Rightarrow C=53.13^\circ$$

Q8. A man raises his left hand in a plane mirror, the image facing him is raising his right hand. Explain why.

Ans: A man raises his left hand in a plane mirror, the image facing him is raising his right hand. This is due to lateral inversion (It is the effect produced by a mirror in reversing images from left to right).

Note: Plane mirror is the only type of mirror which always gives us an image which is virtual, erect and of the same size as that of the object.

Q9. In your own words, explain why light waves are refracted at a boundary between two materials.

Ans: Refraction occurs at the boundary of two media when light travels from one medium into the other and its speed changes but its frequency remains the same. If the light ray hits the boundary at an angle which is not perpendicular to or parallel to the surface, then it will change direction and appear to 'bend'.

The amount of bending depends on the indices of refraction of the two media and is described quantitatively by Snell's Law.

Q10. Why or why not concave mirrors are suitable for make up?

Ans: People use a concave mirror for shaving or make up because when a person stands between the principal focus and pole of a concave mirror, person sees an enlarged, erect and virtual image of his face. This is the reason why a concave mirror of large focal length is used for shaving or make

OR (Second Answer)

When an object is placed within the focal length of a concave mirror, a magnified, erect and virtual image is formed. A concave mirror is therefore used for shaving and makeup purpose.

Q11. Why is the driver's side mirror in many cars convex rather than plane or concave?

Ans: Drivers prefer convex mirrors because:

(i) They always produce erect image of the objects behind the drivers.

(ii) Their field of view is very broad and is able to see more widely. However plane mirror or concave mirror does not give the erect image but their field of view is not broad.

Q12. When an optician's testing room is small, he uses a mirror to help him test the eye sight of his patients. Explain why.

Ans: To increase the distance of eye chart from the patient, the optician using plan mirror in a small room. Which tricks the eye and makes the space seem larger.

The image therefore appears to be the same size as the actual face.

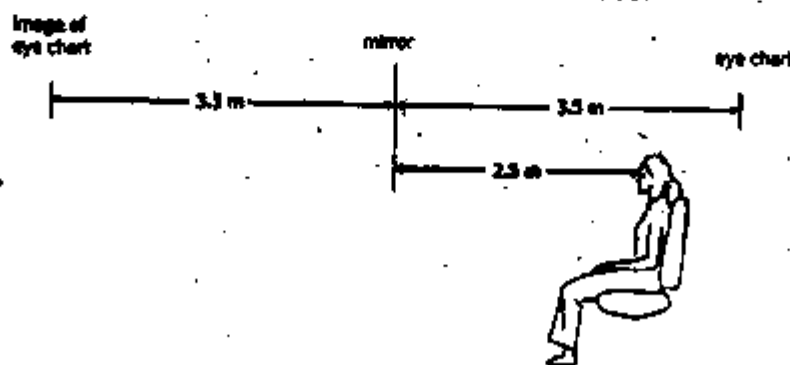



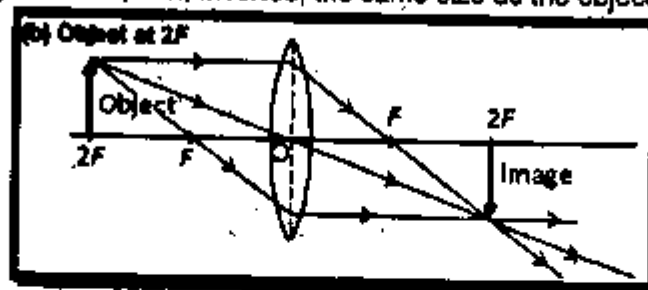
Figure shows a typical setup in an optometrist's examination room. The patient's vision is supposed to be tested at a distance of 6 meters (20 feet), but this distance is larger than the amount of space available in the room. Therefore a mirror is used to create an image of the eye chart behind the wall.

Q13. How does the thickness of lens effect its focal length?

Ans: "As the thickness of the lens increases, the focal length decreases".

If we reduce the thickness of the lens between the curved surfaces then the focal length increases. If you mean making the lens less curved and hence thinner, then the curvature of the interfaces will increase and hence the focal length will increase.

Q14. Under what conditions will a converging lens form a real image that is the same size as the object?

Ans: When an object is placed at 2F then its image is formed on 2F on the other side of the lens having the same size. The image is at 2F, real, inverted, the same size as the object.

Q15. What are the differences between real and virtual images?

Ans: **Real Image:** Real image is formed in front of mirror when rays of light coming from a point on object converge after reflection from mirror. It can be observed on a screen and is always inverted.

Virtual Image: Virtual image is formed behind the mirror when rays of light coming from a point on subject diverge after reflection from a mirror. It cannot be observed on screen. It is always erect.

	Real Image	Virtual Image
i.	Rays actually converge to form image.	Rays appear to diverge.
ii.	Image is inverted	Image is erect
iii.	Can be obtained on screen.	Cannot be obtained on screen

Q16. Define the following terms used in refraction:

(i) Angle of incident (ii) Angle of refraction

Ans: (i) Angle of incident:

The angle that the incident ray makes with the normal line is referred to as the angle of incidence.

(ii) Angle of refraction:

The angle that the refracted ray makes with the normal line is referred to as the angle of refraction.

Q17. Describe the following terms used in reflection:

(i) Normal (ii) angle of incidence (iii) angle of reflection

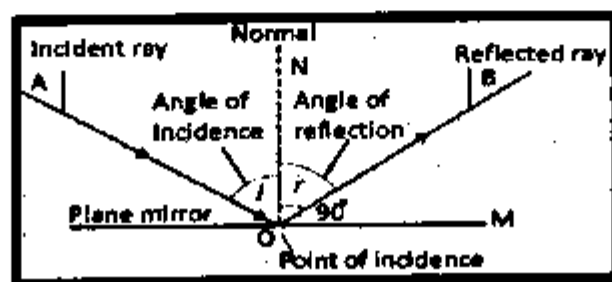
Ans: (i) Normal:

Normal is a line drawn perpendicular to the surface of mirror from point the point where incident ray meets the surface of the mirror.

(ii) Angle of incidence:

The **angle of incidence** is the angle the incident ray makes with the normal drawn at the **point of** incidence of the incident ray on the surface of the mirror.

(iii) Angle of reflection:

The **angle of reflection** is the angle the reflected ray makes with the normal drawn at the **point of incidence**.

Reflection of light

Q18. A convex mirror is used to reflect light from an object placed 66 cm in front of the mirror. The focal length of the mirror is $f = -46$ cm (note the minus sign). Find the location of the image.

Solution: $p = 66$ cm and $f = -46$ cm, using mirror formula.

$$\frac{1}{q}=\frac{1}{f}-\frac{1}{p} \Rightarrow \frac{1}{q}=\frac{1}{46}-\frac{1}{66}$$

$$\frac{1}{q}=-\frac{1}{27} \Rightarrow q=-27\text{ cm}$$

The negative sign indicates that the image is behind the mirror and, therefore, is a virtual image.

Q19. An object is placed 6 cm in front of a concave mirror that has 10 cm focal length. Determine the location of the image.

Solution: we have $p = 6$ cm and $f = 10$ cm, using the mirror formula.

$$\frac{1}{q}=\frac{1}{f}-\frac{1}{p} \Rightarrow \frac{1}{q}=\frac{1}{10}-\frac{1}{6}$$

$$\frac{1}{q}=-\frac{1}{15} \Rightarrow q=-15\,cm$$

The negative sign indicates that the image is virtual i.e. behind the mirror.

Q20. A ray of light enters from air into glass surface. The angle of incidence is 30°. If the refractive index of glass is 1.52, then find the angle of refraction r.

Solution: We have $i = 30°$, $n = 1.52$, using Snell's law

$$\frac{\sin i}{\sin r}=n$$

$1.52 \sin r = \sin 30°$

or $\sin r = \sin 30°/1.52$

$r = 19.3°$

Hence angle of refraction is 19.3°.

Q21. Find the value of critical angle for water if the refracted angle is 90°. The refractive index of water is 1.33 and that of air is 1.

Solution: When light enters in air from water Snell's law becomes

$$\frac{\sin r}{\sin i} = n$$

$$n \sin i = \sin r$$

$$n \sin i = \sin 90°$$

$$n \sin i = 1$$

but $n = 1.33$

Therefore, $$i = \sin^{-1}[1/1.33] = \sin^{-1}(0.752) = 48.8°$$

∴ Critical angle C = 48.8°

Therefore, critical angle of water is 48.8°.

Q22. A person 1.70 m tall is standing 2.5 m in front of a camera. The camera uses a convex lens whose focal length is 0.05 m. Find the image distance (the distance between the lens and the film) and determine whether the image is real or virtual.

Solution: To find the image distance q, we use the thin-lens equation with $p = 2.5$ m and $f = 0.05$ m.

$$\frac{1}{q} = \frac{1}{f} - \frac{1}{p} = [illegible] = 19.8$$

or q = [illegible]

Since the image [illegible] is positive, [illegible] image is formed on the film at the focal point of the lens.

Q23. A concave lens [illegible] [illegible] **of** [illegible]

[illegible] image distance $q = -10$ cm

Focal length $f = -15$cm

Object distance $p = ?$

Using the lens formula:

$$\frac{1}{q} - \frac{1}{p} = \frac{1}{f}$$

$$\frac{1}{p} - \frac{1}{q} = \frac{1}{f}$$

$$= -\frac{1}{10} - \frac{1}{(-15)} = -\frac{1}{10} + \frac{1}{15}$$

$$\frac{1}{p} = -\frac{3+2}{30}$$

$$p = -30cm$$

Thus, the object distance is 30 cm, on the left side from the concave lens.

Magnification of the lens is $m = \frac{q}{p} = \frac{-10}{-30} = \frac{1}{3}$

The image is reduced to one-third ($\frac{1}{3}$) in size than the object. The positive sign shows that the image is erect and virtual.

UNIT 13: ELECTROSTATICS

13.1 Production of electric charges
13.2 Electrostatic induction
13.4 Coulomb's Law
13.5 Electric Field and electric intensity
13.6 Electrostatic Potential
13.7 Capacitors and capacitance

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 4
BASED ON UNIT # 13 (Reduced Syllabus)
ELECTROSTATICS

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. A positive electric charge
A. attracts other positive charge B. repels other positive charge
C. attracts a neutral charge D. repels a neutral charge

ii. An object gains excess negative charge after being rubbed against another object, which is:
A. neutral B. negatively charged
C. positively charged D. either a, b or c

iii. Two uncharged objects A and B are rubbed against each other. When object B is placed near a negatively charged object C, the two objects repel each other. Which of these statements is true about object A?
A. remains uncharged. B. becomes positively charged
C. becomes negatively charged, D. unpredictable

iv. When you rub a plastic rod against your hair several times and put it near some bits of paper, the pieces of papers are attracted towards it. What does this observation indicate?
A. the rod and the paper are oppositely charged. B. the rod acquires a positive charge.
C. the rod and the paper have the same charges. D. the rod acquires a negative charge

v. According to Coulomb's law, what happens to the attraction of two oppositely charged objects as their distance of separation increases?

vi. **The Coulomb's law is valid for the charges which are**
 A. moving and point charges B. moving and non-point charges
 C. stationary and point charges D. stationary and large size charges

vii. **A positive and a negative charge are initially 4 cm apart. When they are moved closer together so that they are now only 1 cm apart, the force between them is**
 A. 4 times smaller than before B. 4 times larger than before
 C. 8 times larger than before D. 16 times larger than before

viii. **Five joules of work is needed to shift 10 C of charge from one place to another. The potential difference between the places is**
 A. 0.5 V B. 2 V C. 5V D. 10V

ix. **Two charged spheres are separated by 2 mm. Which of the following would produce the greatest attractive force?**
 A. +1q and +4q B. – 1q and – 4q
 C. +2q and +2q D. +2q and – 2q

x. **Electric field lines**
 A. always cross each other B. never cross each other
 C. cross each other in the region of strong field
 D. cross each other in the region of weak field

xi. **Capacitance is defined as**
 A. VC B. Q/V C. QV D. V/Q

xii. **SI unit of electric intensity**
 A. Nm^{-1} B. NC^{-1} C. Nm^{-2} D. Nm

Total Marks 53

Note: Attempt any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two [illegible]. Use supplementary answer sheet i.e. [illegible]

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. **How can you show by simple experiments that there are two types of electric charges?**

ii. **Describe the method of charging bodies by electrostatic induction.**

iii. **Two point charges q_1 = 10 μ C and q_2 = 5 μ C are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.**

iv. **The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m apart. Find the value of each charge.**

v. **Two charges repel each other with a force of 0.1 N when they are 5 cm apart. Find the forces between the same charges when they are 2 cm apart.**

vi. **A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V, what would be the energy supplied by the charge?**

vii. **A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.**

viii. **What is meant by electric field and electric intensity?**

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. **Is electric intensity a vector quantity? What will be its direction?**

ii. **How does electrostatic induction differ from charging by friction?**

iii. **Two capacitors of capacitances 6 μ F and 12 μ F are connected in series with 12V battery. Find the equivalent capacitance of the combination.**

v. Two capacitors of capacitances 6 pF and 12 pF are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

vi. How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5×10^{-11} C?

vii. What do you mean by electric field lines? Give their properties also.

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. $(2 \times 10 = 20)$

Q.4 a. Explain Coulomb's law of electrostatics and write its mathematical form.

b. The charge of how many negatively charged particles would be equal to 100 μC. Assume charge on one negative particle is 1.6×10^{-19} C?

Q.5 a. Derive the formula for the equivalent capacitance for a parallel combination of a number of capacitors.

b. The potential at a point in an electric field is 10^4 V. If a charge of +100 μC is brought from infinity to this point. What would be the amount of work done on it?

Q.6 a. How would you define potential difference between two points? Define its unit. Also Show that potential difference can be described as energy transfer per unit charge between the two points.

b. A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solution of Guess Paper & Model Paper # 4

(Reduced Syllabus)

SECTION-A (MCQs)

i. B	ii. A	iii. B	iv. A	v. C	vi. C
vii. D	viii. A	ix. D	x. B	xi. B	xii. B

SECTION – B (Marks 18)

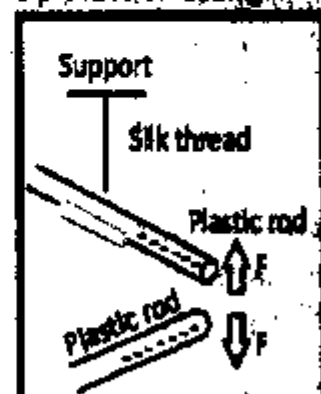
Q.2 Attempt any SIX parts from the following. All parts carry equal marks. $(6 \times 3 = 18)$

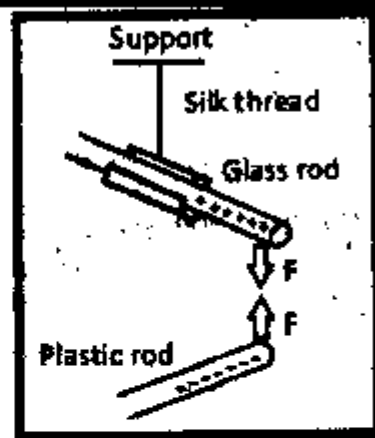
i. How can you show by simple experiments that there are two types of electric charges?

Ans: Production of Electric Charges:

We can produce electric charge by rubbing a neutral body with another neutral body. The following activities show that we can produce two types of electric charges through the process of rubbing.

Activity:

Take a plastic rod. Rub it with fur and suspend it horizontally by a silk thread (Fig). Now take another plastic rod and rub it with fur and bring near to the suspended rod. We will observe that both the rods will repel each other. It means during the rubbing both the rods were charged.

Activity:

Now take a glass rod and rub it with silk and suspend it horizontally. When we bring the plastic rod rubbed with fur near to the suspended glass rod, we observe that both the rods attract each other (Fig). In the first activity, both rods are of plastic and both of them have been rubbed with fur. Therefore, we assume that charge on both rods would be of the same kind.

Plastic rod rubbed with fur and glass rod rubbed with silk attract each other

Result: In the second activity, rods are unlike and their attraction imply that charge on the two rods are not of the same kind but of opposite nature. These apposite charges are conventionally called positive and negative charge.

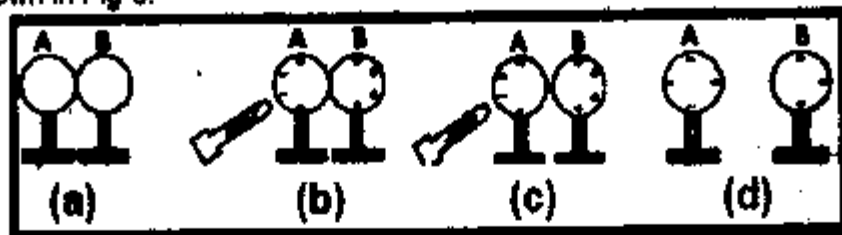
ii. Describe the method of charging bodies by electrostatic induction.

Ans: Activity:

Bring two metal spheres A and Band place them on an insulating stand as shown in Fig-a. Now bring a positively charged rod near sphere A as shown in Fig- b.

Rod will attract negative charge towards it and repel positive charge away from it. Negative charge will be developed on the left surface of the sphere A which is close to the rod. While positive charge will be developed on the right surface of the sphere B.

Now seperate the spheres by a small distance while the rod is still near the sphere A. The two spheres will be oppositely charged and attract each other as shown in Fig-c. Remove the rod. The charges on spheres rearrange themselves as shown in Fig-d.

Now separate the spheres by a large distance. The charges are uniformly distributed over the surfaces of the spheres as shown in Fig-e.

Charging two spheres by electrostatic induction

In this process, an equal and opposite charge will be developed on each metal sphere. This is *charging by induction.*

iii. Two point charges q_1 =10 μC and q_2= 5 μC are placed at a distance of 150 cm. What will be the Coulomb's force between them? Also find the direction of the force.

Solution: $q_1 = 10\mu C q_1 = 10\times10^{-6} C. (1\mu C = 10^{-6} C)$; $q_2 = 5\mu C = 5\times10^{-6}$

Distance = r = 150 cm ; $r = \frac{150}{100} = 1.50\ m$; $k = 9\times10^9\ Nm^2C^{-2}$

According to Coulomb's law

$$F = k\frac{q_1q_2}{r^2} = (9\times10^9)\times\frac{10^{-5}\times5\times10^{-5}}{(1.5)^2} = \frac{9\times5\times10^{9-10}}{2.25} = \frac{4.5}{2.25} = 0.2\ N$$

iv. The force of repulsion between two identical positive charges is 0.8 N, when the charges are 0.1 m apart. Find the value of each charge.

Solution: Force = F = 0.8 N ; Since Charges are identical so $q_1 = q_2 = q$; Distance = r = 0.1 m

$k = 9\times10^9\ Nm^2C^{-2}$; Value of each charge = q = ?

According to Coulomb's law $F = k\frac{q_1q_2}{r^2}$

Re-arrange for charge q we get: $q^2 = \frac{Fr^2}{k} \Rightarrow \quad q^2 = \frac{0.8 \times (0.1)^2}{9 \times 10^9} = \frac{0.8 \times 0.01}{9 \times 10^9} \Rightarrow q = \sqrt{\frac{8 \times 10^{-3}}{9 \times 10^9}}$

Solution: Force = F = 0.1 N ; distance = r = 5 cm = 0.05 m ; $k = 9 \times 10^9\ Nm^2C^{-2}$
Force = F = ? (When r = 2 cm = 0.02 m)

According to Coulomb's law $F = k\frac{q_1 q_2}{r^2}$ ... ... (i) $\Rightarrow$ Re-arrange for changes $q_1\,q_2 = \frac{Fr^2}{k}$..........(ii)

Putting values we get: $q_1\,q_2 = \frac{0.1 \times (0.05)^2}{9 \times 10^9}$ ....

(iii) By putting value of $q_1\,q_2$ and r = 2 cm = 0.02 m in (i) we get $F = K\frac{q_1 q_2}{r^2}$

$$F = (9 \times 10^9) \times \frac{0.1 \times (0.05)^2}{9 \times 10^9} \times \frac{1}{(0.02)^2} \Rightarrow F = \frac{(0.1 \times 0.05)^2}{(0.02)^2} = \frac{0.1 \times 0.0025}{0.0004} = \frac{0.00025}{0.0004} = 0.62\ N$$

vi. A point charge of +2C is transferred from a point at potential 100V to a point at potential 50V, what would be the energy supplied by the charge?

Solution: Higher potential = $V_1 = 100\ V$; Lower potential = $V_2 = 50\ V$
Potential difference = $\Delta V = V_2 - V_1 = 100 - 50 = 50\ V$; Charge = q = +2 C ; Work done = W = ?

Since $W = q\Delta V \Rightarrow W = 50 \times 2 \Rightarrow W = 100$ joules

vii. A capacitor holds 0.06 coulombs of charge when fully charged by a 9 volt battery. Calculate capacitance of the capacitor.

Solution: Charge = Q = 0.06 C ; Potential = V = 9 Volts , Capacitance = C = ?

Since $Q = CV \Rightarrow C = \frac{Q}{V} \Rightarrow C = \frac{0.06}{9} = 6.67 \times 10^{-3}\ F$

viii. What is meant by electric field and electric intensity?

Ans: Electric Field:

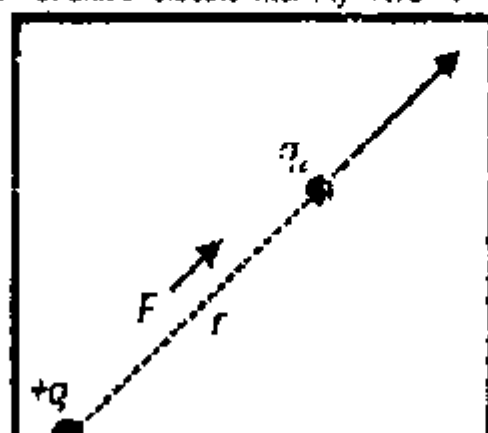
The electric field is a region around a charge in which it exerts electrostatic force on another charges.

Electric Field Intensity:

The strength of an electric field at any point in space is known as electric field intensity.

$$E = \frac{F}{q_0} \text{ .... (i)}$$
$$F = qE \text{ .... (ii)}$$

Thus the electric field intensity at any point is defined as the force acting on a unit positive charge placed at that point.

Unit of Electric Field Intensity: SI unit of electric intensity is NC^{-1}.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Is electric intensity a vector quantity? What will be its direction?

Ans: Electric intensity being a force is a vector quantity. Its direction is the same as that of the force acting on the positive test charge. If the test charge is free to move, it will always move in the direction of electric intensity.

ii. How does electrostatic induction differ from charging by friction?

Ans:

Transforming Charges	Objects become charged when electrons are transformed from one location to another.
Charging By Friction	Transfer of electrons from one object to another by rubbing.
Charging By Conduction	Electrons transfer from object that has negative charges to positive charge object.
Charging by Induction	Electrons move to one part of an object because it is in the electric field of another object.
Static Discharge	The loss of static has negative charge transfer from one object to another.
Three methods of charging	Friction, Conduction and Induction
Charging By Friction Example	Clothes rubbing together in a dryer, feet rubbing on a carpet.
Charging by Conduction Example	Foot becomes charged by friction; rest of body becomes charged because it has contact with foot.
Charging by Induction Example	Electrons on fingertips cause electrons on doorknob to move away, leaving doorknob with a positive charge.

iii. Two capacitors of capacitances 6 μF and 12 μF are connected in series with 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution: $C_1 = 6.0\ \mu F = 12.0 \times 10^{-6} F$

$C_2 = 12.0\ \mu F = 12.0 \times 10^{-6} F$ we know $1\ \mu F = 10^{-6}\ F$

$V = 12$ Volts

(i) Equivalant Capacitance = $C_e = ?$

(ii) Charge on each Capacitor = $Q = ?$

(iii) Potentail cdifference across each capacitor = $V = ?$

(i) Since capacitors are connected in series combination

$$\frac{1}{C_e} = \frac{1}{C_1} + \frac{1}{C_2} \quad \Rightarrow \quad \frac{1}{C_e} = \frac{1}{6} + \frac{1}{12}$$

$$\frac{1}{C_e} = \frac{1+2}{12} \quad \Rightarrow \quad \frac{1}{C_e} = \frac{3}{12}$$

$$\frac{1}{C_e} = \frac{1}{4} \quad \Rightarrow \quad C_e = 4.0\ \mu F$$

(ii) In series combination, charge across each capacitor is same therefore

$Q = C_e V$

$Q = (4.0\ \mu F) \times (12\ V)$

$Q = 48 \mu C$

(iii) Voltage across the capacitor C_1 is $V_1 = \frac{Q}{C_1} = \frac{48\mu C}{6\mu F} = 8$ Volts

Voltage across the capacitor C_2 is $V_2 = \frac{Q}{C_2} = \frac{48\mu C}{12\mu F} = 4$ **Volts**

iv. What do you mean by the capacitance of a capacitor? Define units of capacitance.

Ans: Capacitance:

Capacitance is the ability of the capacitor to store charge. It is given by the ratio of charge and the electric potential as-

$$C = \frac{Q}{V}$$

Unit of Capacitance: SI unit of capacitance is farad (F), defined as:

Farad: *If one coulomb of charge given to the plates of a capacitor produces a potential difference of one volt between the plates of the capacitor then its capacitance would be one farad.*

v. Two capacitors of capacitances 6 pF and 12 pF are connected in parallel with a 12V battery. Find the equivalent capacitance of the combination. Find the charge and the potential difference across each capacitor.

Solution: $C_1 = 6.0\ \mu F = 3.0 \times 10^{-6}\ F$

$C_2 = 12.0\ \mu F = 12.0 \times 10^{-6}\ F$

$V = 12\ Volts$

(i) Equivalant Capacitance = $C_e = ?$

(ii) Charge on each Capacitor = $Q = ?$

(iii) Potentall cdifference across each capacitor = $V = ?$

(i) Since capacitor are connected in parallel combination

$$C_e = C_1 + C_2$$

$$C_e = 6.0\ \mu F + 12.0\ \mu F$$

$$C_e = 18.0\ \mu F$$

(ii) Charge on each capacitor:

The charge on $C_1 = 6.0\ \mu F$ capacitor is given by.

$$Q_1 = C_1 V$$

$$Q_1 = (6.0 \times 10^{-6}) \times (12)$$

$$Q_1 = 72.0\ \mu C$$

The charge on $C_2 = 4.0\ \mu F$ capacitor is given by.

$$Q_2 = C_2 V$$

$$Q_2 = (12.0 \times 10^{-6}) \times (12)$$

$$Q_2 = 144\ \mu C$$

(ii) Since the three capacitors are connected in parallel, so voltage across each capacitor is the same that is equal to the applied voltage. Hence

$$V_1 = V_2 = V = 12\ \text{Volts}$$

vi. How much negative charge has been removed from a positively charged electroscope if it has a charge of 7.5×10^{-11} C?

Ans: According to phenomenon of electrostatic induction, the amount of charge induces will be equal to amount of charge displaced. So **-7.5×10^{-11}** C has been removed from a positively charged electroscope if it has a charge of **7.5×10^{-11}** C.

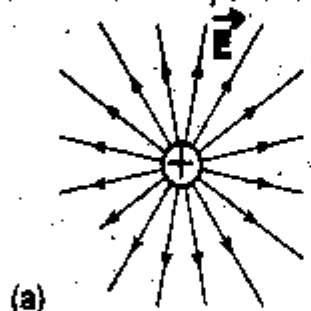
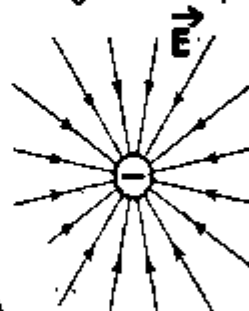
vii. What do you mean by electric field lines? Give their properties also.

Ans: Electric Field Lines:

The direction of electric field intensity in an electric field can also be represented by drawing lines. These lines are known as electric lines of force. These lines were introduced by Michael Faraday.

The field lines are imaginary lines around a field charge with an arrow head indicating the direction of force.

Properties of Electric Field Lines:

iii. The electric field intensity is tangent to the electric field lines at each point (Fig-a).
iv. The number of lines per unit area through a surface perpendicular to the lines is proportional to the electric field strength in a given region (Fig-b).
v. Electric field is strong when the field lines are close together and weak when the lines are far apart.
vi. No two field lines cross each other.
Electric field lines for an isolated positive and negative point charges are shown below:

(a)
Electric field lines for an isolated positive point charge

(b)
Electric field lines for an isolated negative point charge

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **($2 \times 10 = 20$)**

Q.4 a. Explain Coulomb's law of electrostatics and write its mathematical form.

Ans: Coulomb's Law:

The force of attraction or repulsion between two point charges is directly proportional to the product of the quantity of charges and inversely proportional to the square of the distance between them.

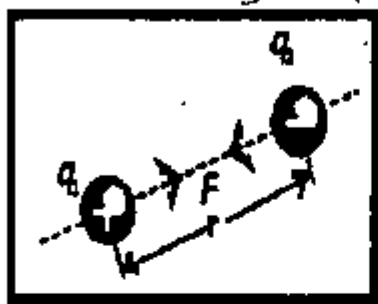
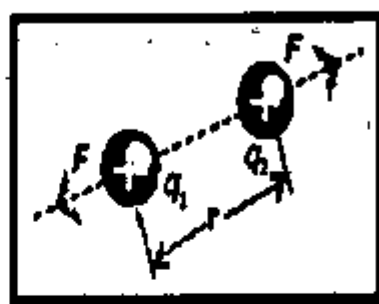
Mathematical form of Coulomb's Law:

$$F \propto q_1 q_2 \text{ .... (i)}$$

$$F \propto \frac{1}{r^2} \text{ .... (ii)}$$

Combining Equation. (i) and (ii), we get $$F = k\frac{q_1 q_2}{r^2} \text{ .... (iii)}$$

Equation (iii) is known as Coulomb's law.

Note: Now if the medium between the two charges is air then the value of k in SI units will be $9\times 10^9\ Nm^2C^{-2}$.

Attraction between opposite charges

Repulsion between similar charges

b. The charge of how many negatively charged particles would be equal to 100 μC. Assume charge on one negative particle is 1.6×10^{-19} C?

Solution: Charge = $q = 100\mu C = 100\times10^{-6}$. ($1\mu C = 10^{-6}C$)
Charge on one negative particle (electron) = e = 1.6×10^{-19}C
Number of negatively charged particles = n = ?

Since $q = ne \Rightarrow n = \frac{q}{e} \Rightarrow n = \frac{100\times10^{-6}}{1.6\times10^{-19}}$

$n = 6.25\times10^{19-6} \Rightarrow n = 6.25\times10^{13}$

Q.5 a. Derive the formula for the equivalent capacitance for a parallel combination of a number of capacitors.

Ans: See Q4., Past FBISE Paper (2019), Page # 130.

b. The potential at a point in an electric field is 10^4 V. If a charge of +100 μC is brought from infinity to this point. What would be the amount of work done on it?

Solution: Potential = V = 10^4 V

Charge = q = 100μC = q = 100×10^{-6}C = $10^{-4}C$ ($1\mu C = 10^{-6}C$)

Work done = W = ?

Since $W = qV \Rightarrow W = 10^{-4} \times 10^4 \Rightarrow W = 10^0 = 1$ joule

Q.6 a. How would you define potential difference between two points? Define its unit. Also, show that potential difference can be described as energy transfer per unit charge between the two points.

Ans: Potential Difference: We define potential difference between two points as:

The energy supplied by a unit charge as it moves from one point to the other in the direction of the field.

Unit of Potential Difference:

Electric potential is a scalar quantity. Its SI unit is volt which is equal to JC^{-1}.

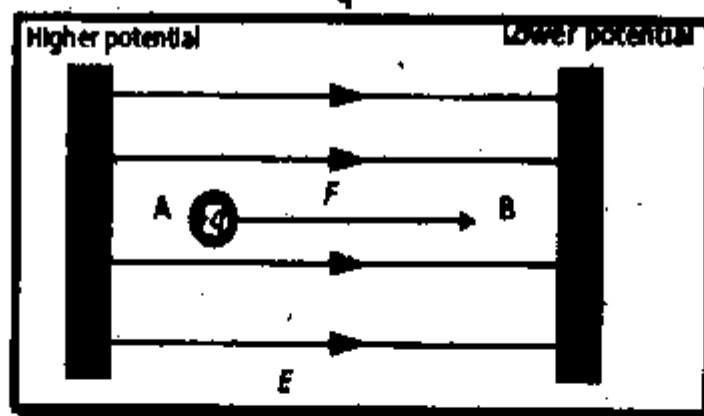
Volt: If one joule of work is done against the electric field in bringing one coulomb positive charge from infinity to a point in the electric field then the potential at that point will be one volt.

Or if the potential energy of one coulomb of charge at a point in the electric field is one joule, the potential of that point will be one volt.

Potential Difference as Energy Transfer:

Electric potential at a point in an electric field is equal to the amount of work done in bringing a unit positive charge from infinity that at point.

If W is the Work done in moving a unit positive charge from infinity to a certain point in the field, the electric potential V at this point would be given by

$$V = \frac{W}{q} \text{ .... (i)}$$

Potential difference between two points

If the potential of point A is V_a, and that of point B is V_b, the potential energy of the charge at these points will be qV_a and qV_b respectively. The change in potential energy of the charge when it moves from point A to B will be equal to $qV_a - qV_b$. This energy is utilized in doing some useful work. Thus

Energy supplied by the charge = $q(V_a - qV_b)$ ....(ii)

b. A capacitor holds 0.03 coulombs of charge when fully charged by a 6 volt battery. How much voltage would be required for it to hold 2 coulombs of charge?

Solution: Charge = Q = 0.03 C ; Potential = V = 6 Volts ; Voltage = ? (*When Q = 2 C*)

$$Q = CV \Rightarrow C = \frac{Q}{V} \Rightarrow C = \frac{0.03}{6}; \quad C = 0.005\,F \text{ ....(i)}$$

Now Voltage V = ?

When Q = 2 C $V = \frac{Q}{C} \Rightarrow V = \frac{2}{0.005} = 400\text{ V}$

IMPORTANT QUESTIONS & ANSWERS

Q1. An electrified rod attracts pieces of paper. After a while these pieces fly away! Why?

Ans: Electrified rod has more number of electrons when we took this rod near to the piece of paper which is neutral the charge from rod shifts to the paper after the transfer of charge the paper get charged and now both have equal number on electrons. Now these electrons exert a repulsive force on each other. That's why after a while paper pieces fly away.

Q2. Each capacitor in parallel combination has equal potential difference between its two plates. Justify the statement.

Ans: As current flow in each capacitor is same that's why the potential of each capacitor across its plates is same. $V_1 = V_2 = V_3 = V$

Q3. Perhaps you have seen a gasoline truck trailing a metal chain beneath it. What purpose does the chain serve?

Ans: A metallic chain can be seen hanging from the rear side of a petrol supply tanker. This chain (Conductor) rolls on the road as the tanker moves. Due to friction with air, the body of tanker gets charged and tinny spark can cause a havoc (*To destroy*). This charge is continuously being transferred to ground through the metallic chain. Thus the danger of spark is eliminated.

Q4. Explain why, a glass rod can be charged by rubbing when held by hand but an iron rod cannot be charged by rubbing, if held by hand?

Ans: Because iron is a conductor so when we rub it then electrons move within the conductor and did not become static on the other hand glass rod is an insulator and when we rub, it get charge on its surface and act like a charged body.

Q5. A strong electric field exists in the vicinity of this "Faraday cage". Yet the person inside the cage is not affected. Can you tell why?

Ans: A Faraday cage operates because an external static electrical field causes the electric charges within the cage's conducting material to be distributed such that they cancel the field's effect in the cage's interior (Electric field becomes zero inside the interior of Faraday's cage). This phenomenon is used, for example, to protect electronic equipment from lightning strikes and electrostatic discharges. That is why the person inside the cage is not affected.

Note: *A Faraday cage is a metallic enclosure that prevents the entry or escape of an electromagnetic (EM) field.*

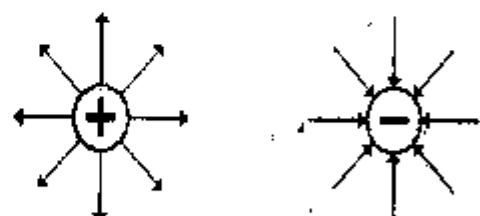
Q6. Capacitor blocks dc but allows ac to pass through a circuit. How does this happen?

Ans: When used in a direct current or DC circuit, a capacitor charges up to its supply voltage but blocks the flow of current through it because the dielectric of a capacitor is non-conductive and basically an insulator. However, when a capacitor is connected to an alternating current or AC circuit, the flow of the current appears to pass straight through the capacitor with little or no resistance. AC appears to flow because the capacitor is constantly charging and discharging.

Q7. In what direction will a positively charged particle move in an electric field?

Ans:

Electric field is a vector quantity whose direction is defined as the direction that a positive test charge would be pushed when placed in the field. Thus, the electric field direction about a positive source charge is always directed away from the positive source. And the electric field direction about a negative source charge is always directed toward the negative source.

Direction of an Electric Field

The electric field direction is always directed away from positive source charges and towards negative source charges.

Q8. Two bodies are oppositely charged with 500 μC and 100 μC. Find the force between the two charges if the distance between them in air is 0.5m.

Solution: Given, $q_1 = 500\ \mu C\ 500 \times 10^{-6}$ C,

$q_2 = 100\ \mu C = 100 \times 10^{-6}$ C,

Distance between charges r = 0.5m

Substituting these values in equation of Coulomb's law, we have

$$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2} = \frac{9 \times 10^9\ Nm^2 c^{-2} \times 500 \times 10^{-6}\ C \times 100 \times 10^{-6}\ C}{(0.5m)^2}$$

$$F = 1800\ N$$

Q9. The capacitance of a parallel plate capacitor is 100 μF. If the potential difference between its plates is 50 volts, find the quantity of charge that capacitor can store. What will be the charge on each plate?

Solution: Given that; Potential difference between the plates V = 50V

Capacitance $C = 100\ \mu F = 100 \times 10^{-6}$ F.

Charge $Q = ?$

Using the formula $Q = CV$

Putting the values $Q = 100 \times 10^{-6}\ F \times 50V \quad = 5 \times 10^{-3}\ C = 5\ mC$

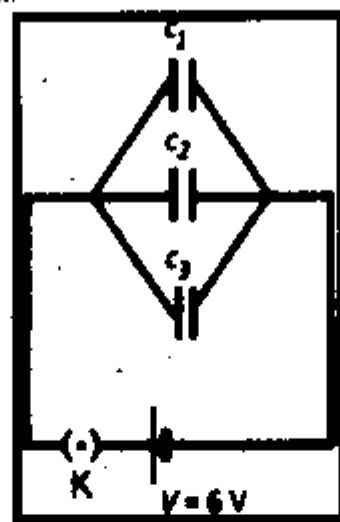
Charge on each plate will be 5 mC, because each plate has equal amount of charge. Capac Capacitors are manufactured with different standard capacitances, and by combining them in series or in parallel, we can get any desired value of the capacitance.

Q10. Three capacitors with capacitances of 3.0 μF, 4.0 μF, and 5.0 μF are arranged in parallel combination with a battery of 6V (1 μF = 10^{-6} F). Find

A. The total capacitance

B. The voltage across the capacitors

C. The quantity of charge on each plate of the capacitor.

Solution: Diagram is shown on right.

A. Total capacitance is given by

$$C_{eq} = C_1 + C_2 + C_3$$

$$C_{eq} = 3.0 \times 10^{-6}\ F + 4.0 \times 10^{-6}\ F + 5.0 \times 10^{-6}\ F$$

$$C_{eq} = (3 + 4 + 5) \times 10^{-6}\ F = 12 \times 10^{-6}$$

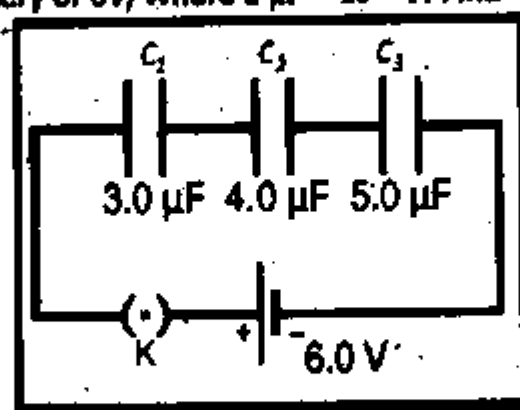
$$C_{eq} = 12\ \mu F$$

B. As three capacitors are connected in parallel, the voltage across each capacitor will be same and is equal to the voltage of the battery i.e. 6 V.

C. Charge on a capacitor with capacitance C_1

$Q_1 = 18\ \mu C$

Similarly charge on capacitors with capacitance C_2 and C_3 is 24 µC and 30 µC respectively.

Q11. Three capacitors with capacitances of 3.0 µF, 4.0 µF, and 5.0 µF are arranged in series combination to a battery of 6V, Where 1 µF = 10^{-6} F. Find

a. The total capacitance of the series combination.
b. The quantity of charge across each capacitor.
c. The voltage across each capacitor.

Solution: (a) Diagram is shown on right. For total capacitance,

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$$

$$\frac{1}{C_{eq}} = \frac{1}{3.0 \times 10^{-6}\,F} + \frac{1}{4.0 \times 10^{-6}\,F} + \frac{1}{5.0 \times 10^{-6}\,F}$$

$$\frac{1}{C_{eq}} = \left[\frac{1}{3} + \frac{1}{4} + \frac{1}{5}\right] \times \frac{1}{10^{-6}\,F}$$

$$\frac{1}{C_{eq}} = \frac{47}{60} \times \frac{1}{10^{-6}\,F}$$

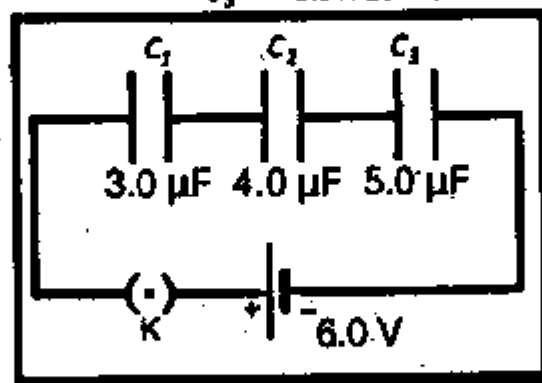
$$C_{eq} = 1.3\ \mu F$$

(b) In series combination, charge across each capacitor is same and can be found as:

Q = VC = (6.0V) (1.3× 10^{-6} F) = 7.8 μC

(c) Voltage across capacitor $C_1 = V_1 = \frac{Q}{C_1} = \frac{7.8 \times 10^{-6}\,C}{3.0 \times 10^{-6}\,F} = 2.6V$

Voltage across capacitor $C_2 = V_2 = \frac{Q}{C_2} = \frac{7.8 \times 10^{-6}\,C}{4.0 \times 10^{-6}\,F} = 1.95V$

Voltage across capacitor $C_3 = V_3 = \frac{Q}{C_3} = \frac{7.8 \times 10^{-6}\,C}{5.0 \times 10^{-6}\,F} = 1.56V$

UNIT 14: CURRENT ELECTRICITY

All theory topics from 14.1 - 14.11

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 5
BASED ON UNIT # 14 (Reduced Syllabus)
CURRENT ELECTRICITY

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. An electric current in conductors is due to the flow of
A. positive ions. B. negative ions.
C. positive charges D. free electrons

ii. What is the voltage across a 6 Ω resistor when 3 A of current passes through it?
A. 2 V B. 9 V C. 18 V D. 36 V

iii. What happens to the intensity or the brightness of the lamps connected in series as more and more lamps are added?
A. increases B. decreases
C. remains the same D. cannot be predicted

iv. Why should household appliances be connected in parallel with the voltage source?
A. to increase the resistance of the circuit
B. to decrease the resistance of the circuit
C. to provide each appliance the same voltage as the power source.
D. to provide each appliance the same current as the power source.

v. Electric potential and e.m.f
A. are the same terms B. are the different terms
C. have different units D. both (b) and (c)

vi. When we double the voltage in a simple electric circuit, we double the
A. current B. power C. resistance D. both (a) and (b)

vii. If we double both the current and the voltage in a circuit while keeping its resistance constant, the power
A. remains unchanged

viii. What is the power rating of a lamp connected to a 12 V source when it carries 2.5 A?
A. 4.8 W B. 4.5 W C. 30 W D. 60 W

ix. The combined resistance of two identical resistors, connected in series is 8 Ω. Their combined resistance in a parallel arrangement will be
A. 2 Ω. B. 4 Ω. C. 8 Ω. D. 12 Ω.

x. According to Coulomb's law, what happens to the attraction of two oppositely charged objects as their distance of separation increases?
A. increases B. decreases
C. remains unchanged D. cannot be determined

xi. The unit of e.m.f which is equal to volt in SI system is?
A. JC^{-1} B. Jm^{-1} C. JS^{-1} D. J

xii. A resistor having resistance 6.2Ω is connected across a battery of 5V using a wire of negotiable resistance. Current passes through the resistor are 0.4A. The total power produced by the battery is
A. 2W B. 3W C. 5W D. 6W

Time allowed: 2:40 Hours **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet–B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. Define and explain the term electric current.
ii. What is the difference between electronic current and conventional current?
iii. What do we mean by the term e.m.f.? Is it really a force? Explain.
iv. How can we differentiate between e.m.f. and potential difference?
v. Define resistance and its units.
vi. What is the difference between conductors and insulators?
vii. At 100,000 Ω, how much current flows through your body if you touch the terminals of a 12 V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would you receive from the same battery?
viii. Determine the equivalent resistance of series combination of resistors.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. An electric bulb is marked with 220V, 100W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily; find the energy in kilowatt-hour consumed by the bulb in one month (30 days).
ii. Two resistances of 2 kΩ and 8 kΩ are joined in series, if a 10 V battery is connected across the ends of this combination, find the following quantities:
(a) The equivalent resistance of the series combination.
(b) Current passing through each of the resistances.
(c) The potential difference across each resistance.
iii. Design a circuit diagram for a study room that needs the following equipment in parallel:
(a) One 100 W lamp operated by one switch;
(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.
(c) What is the advantage of connecting the equipments in parallel instead of series?
iv. Why in conductors charge is transferred by free electrons rather than by positive charges?

vii. Two points on an object are at different electric potentials. Does charge necessarily flow between them?

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. $(2 \times 10 = 20)$

Q.3 a. Explain Ohm's law. What are its limitations?
b. A current of 3 mA is flowing through a wire for 1 minute. What is the charge flowing through the wire?

Q.4 a. Explain the energy dissipation in a resistance. What is Joule's law?
b. The resistance of a conductor wire is 10 $M\Omega$. If a potential difference of 100 volt is applied across its ends, then find the value of current passing through it in mA.

Q.5 a. Discuss the main features of parallel combination of resistors.
b. By applying a potential difference of 10 V across a conductor a current of 1.5 A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution of Guess Paper & Model Paper # 5
(Reduced Syllabus)

SECTION- A (MCQs)

i. D	ii. C	iii. B	iv. C	v. D	vi. B
vii. C	viii. C	ix. A	x. C	xi. A	xii. A

SECTION – B (Marks 18)

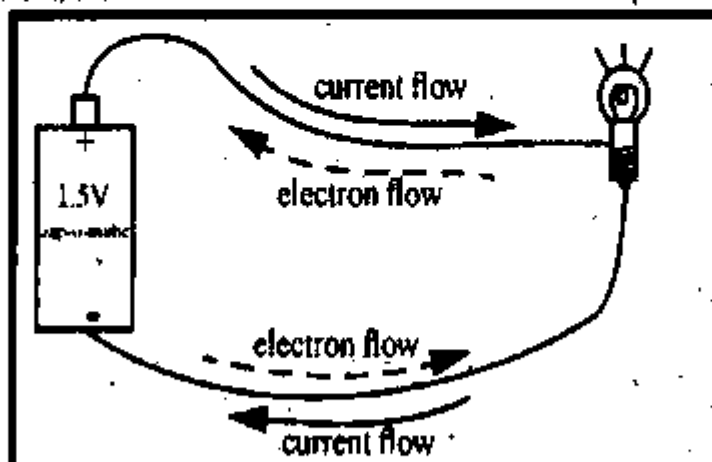
Q.2 Attempt any SIX parts from the following. All parts carry equal marks. $(6 \times 3 = 18)$

i. Define and explain the term electric current.

Ans: See Q2. (xv), Past FBISE Paper (2017), Page # 116.

ii. What is the difference between electronic current and conventional current?

Ans: Difference between electronic current and conventional current:

i. Electronic current can be either negative or positive, but conventional current is always positive.
ii. The conventional current for an electron flow is positive, whereas the Electronic current is negative.
iii. For a flow of positive charges, both the electronic current and the conventional current are the same.
iv. Since almost every electrical circuit uses an electron flow, it can be safely stated that the $conventional\ current = -\ electronic\ current$.
v. In conventional current, the flow of electrons is assumed as a flow of protons on the opposite direction.

iii. What do we mean by the term e.m.f.? Is it really a force? Explain.

Ans: Electromotive Force (e.m.f):

It is the energy supplied by a battery to a unit charge when it flows through the closed circuit.

OR

The energy converted from non electrical forms to electrical form when one coulomb of positive charge passes through

$$e.m.f = \frac{Energy}{Charge} \quad or \quad E = \frac{W}{Q}$$

Where E is the e.m.f., W is energy converted from nonelectrical forms to electrical form and Q is positive charge.

Unit of e.m.f.: The unit for e.m.f. is JC^{-1} which is equal to volt (V) in SI system.

Hence if the e.m.f. of the battery is 2V, the total energy supplied by the battery is 2 joules when one coulomb of charge flows through the closed circuit.

Source of electromotive force (e.m.f.):

A source of electromotive force (e.m.f.) converts non-electrical energy (chemical, thermal, mechanical etc.) into electrical energy. Examples of sources of e.m.f. are batteries, thermocouples and generators. When a conductor is connected to a battery, current flows through it due to potential difference.

e.m.f. is not a force:

Electromotive force (e.m.f.) is actually a voltage between the terminals of the battery, when no current flows in the circuit. The emf represents energy per unit charge (voltage) which has been made available by the generating mechanism (Batteries etc.) and is not a "force".

Note: The term e.m.f. is retained for historical reasons. It is useful to distinguish voltages which are generated from the voltage changes which occur in a circuit as a result of energy dissipation, e.g., in a resistor.

iv. How can we differentiate between e.m.f. and potential difference?

Ans: Difference between e.m.f. and potential difference:

Electromotive force and potential difference are not same. They have following differences:-

	Electromotive force	**Potential difference**
i.	The potential difference between the two terminals of a cell is called electromotive force in an open circuit.	Bringing a unit positive charge from one point to another point in a circuit is called potential difference between two points.
ii.	Electromotive force transmits current both inside and outside the cell.	Potential difference current transfers between any two points in the circuit.
iii.	Electromotive force emf is the cause.	Potential difference is the result/effect.
iv.	Electromotive force is always greater than potential difference.	Potential difference is always less than electromotive force.
v.	Electromotive force creates potential difference entire the circuit.	Potential difference takes place between any two points in the circuit.
vi.	Electromotive force does not depend on the resistance of the circuit.	Potential difference of two points depends on the resistance of those points.
vii.	Electromotive force remains constant.	It does not remain constant.

v. Define resistance and its units.

Ans: Resistance:

The property of a substance which offers opposition to the flow of current through it is called its resistance.

This opposition comes from the collisions of moving electrons with atoms of the substance.

Unit of Resistance:

Ohm: *When a potential difference of one volt is applied across the ends of a conductor and one ampere of current passes through it, then its resistance will be one ohm.*

vi. What is the difference between conductors and insulators?

The highest energy band occupied by electrons is the valence band. In a conductor, the valence band is partially filled, and since there are numerous empty levels, the electrons are free to move under the influence of an electric field; thus, in a metal the valence band is also the conduction band.

Examples: Some common conductors are copper, aluminum, gold, and silver.

Insulators: Insulators are those materials in which valence electrons are bound very tightly to their atoms and are not free.

In an insulator, electrons completely fill the valence band; and the gap between it and the next band, which is the conduction band, is large. The electrons cannot move under the influence of an electric field unless they are given enough energy to cross the large energy gap to the conduction band.

Examples: Some common insulators are glass, air, plastic, rubber, and wood.

vii. At 100,000 Ω, how much current flows through your body if you touch the terminals of a 12 V battery? If your skin is wet, so that your resistance is only 1000 Ω, how much current would you receive from the same battery?

Solution: Resistance = R = 100, 000 Ω = $10^5\,\Omega$; Voltage = $V = 12\,V$

New Resistance = $R' = 1000\,\Omega = 10^3\,\Omega$

(i) Current = I = ? (ii) Current = I' = ?

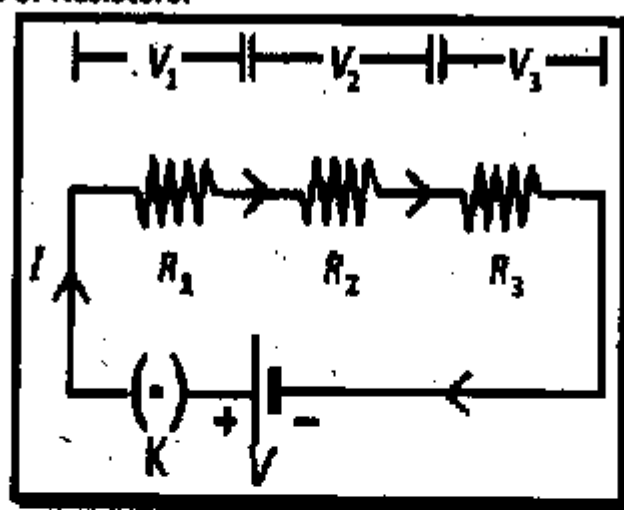
(i) By using ohm's law $V = IR$

$$I = \frac{V}{R} \Rightarrow I = \frac{12V}{10^5\,\Omega} = \frac{12}{10} \times 10^{-4}\,V\Omega^{-1} = 1.2 \times 10^{-2}\,A$$

(ii) Again by using ohm's law $V = I'R'$

$$I' = \frac{V}{R'} \Rightarrow I' = \frac{12V}{10^3\,\Omega} = \frac{12}{10} \times 10^{-2}\,V\Omega^{-1} = 1.2 \times 10^{-2}\,A$$

viii. Determine the equivalent resistance of series combination of resistors.

Ans: Series Combination of Resistors:

Three Resistors in series combination

i. The current is the same in every resistor; this current is equal to that in the battery.

$$I = I_1 = I_2 = I_3$$

ii. The sum of the voltage drops across the individual resistors is equal to the voltage rating of the battery.

$$V = V_1 + V_2 + V_3$$

iii. The overall resistance of the collection of resistors is equal to the sum of the individual resistance values,

$$R_e = R_1 + R_2 + R_3$$

If resistances $R_1 + R_2 + R_3 + \ldots\ldots + R_n$ are connected in series, then the equivalent resistance of

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. An electric bulb is marked with 220V, 100W. Find the resistance of the filament of the bulb. If the bulb is used 5 hours daily; find the energy in kilowatt-hour consumed by the bulb in one month (30 days).

Solution: Voltage = V = 220 V ; Power = W = 100 V ; Time = t = 5 hours ; One month = 30 days
(i) Resistance = R = ? (ii) Energy in kilowatt hour = E = ?

(i)
$$P = \frac{V^2}{R} \implies R = \frac{V^2}{P}$$

By putting the values we get
$$R = \frac{(220)^2}{1000} = \frac{48400}{100} = 484\,\Omega$$

(ii) Energy in kilowatt hour = E = $\frac{Watt \times time\ in\ hours}{1000} = \frac{100 \times 5 \times 30}{1000}$

Energy in kilowatt hour = 15 kWh

ii. Two resistances of 2 kΩ and 8 kΩ are joined in series, if a 10 V battery is connected across the ends of this combination, find the following quantities:
(a) The equivalent resistance of the series combination.
(b) Current: passing through each of the resistances.
(c) The potential difference across each resistance.

Solution: Given Data: Resistance = $R_1 = 2K\Omega$; Resistance = $R_2 = 8K\Omega$
Voltage = V = 10 Volts
(a) Equivalent resistance R_e = ?
(b) Current through each resistor I = ?
(c) Potential across each resistor V_1 = ? and V_2 = ?

(a) As the resistances are connected in series
$$R_e = R_1 + R_2$$
$$R_e = 2\,k\Omega + 8\,k\Omega$$
$$R_e = 10\,k\Omega$$

(b) For series, current will be same through all resistors. BY ohm's law
$$V = IR \qquad I = \frac{V}{R_e}$$
$$I = \frac{10V}{10k\Omega} = \frac{10V}{10000\Omega} = \frac{1\,V}{1000\,\Omega}$$
$$I = 1.0 \times 10^{-3} A = 1\,mA$$

(c) The potential differences across R_1 is $V_1 = IR_1$
$$V_1 = (10^{-3}A) \times (2 \times 10^3 \Omega) = 2\,V$$
Similarly the potential difference across R_2 is $V_2 = IR_2$
$$V_2 = (10^{-3}A) \times (8 \times 10^3 \Omega)$$
$$V_2 = 8\ Volts$$

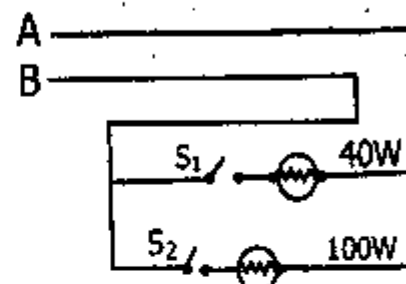
iii. Design a circuit diagram for a study room that needs the following equipment in parallel:
(a) One 100 W lamp operated by one switch;
(b) One reading lamp fitted with a 40 W bulb which can be switched ON and OFF from two points.
(c) What is the advantage of connecting the equipments in parallel instead of series?

Ans: The circuit diagram for the part (a) and (b):

There are two advantages of connecting bulbs in parallel.

i. All the bulbs get the full battery voltage so they're all bright

ii. They're all in their own conducting loop so you can turn one bulb off without affecting the others.

iii. All household lights and appliances are connected in parallel because a parallel circuit allows all devices to operate on the same voltage.

iv. **Why in conductors charge is transferred by free electrons rather than by positive charges?**

Ans: Because electrons are free in conductor and they are in majority. When we apply an external electric field with the help of a battery (source of emf) then these free electrons move from negative to positive terminal of battery. On the other side, positive charges are present in the nucleus of the atom and they are not free to move that's why electric current is caused by free electrons.

v. **What is the difference between a cell and a battery?**

Ans: The difference between cells and batteries is that a cell is a single unit which converts chemical energy to electrical energy to deliver a voltage while a battery is composed of a number of cells in series to get increased voltage. A battery can therefore, also be referred to as cells.

vi. **Can current flow in a circuit without potential difference?**

Ans: No, emf is responsible for the flow of current. When we apply a battery to the ends of a conductor then due to the potential difference between the ends of battery free electrons in the conductor move and respond to the external electric field applied. So, we can say that without potential difference there is no concept of current flow.

vii. **Two points on an object are at different electric potentials. Does charge necessarily flow between them?**

Ans: Electric current flow due to the potential difference. If the object is conductor and there is a potential difference occurs between two different points then electric current will flow. But if the object is insulator then no current will flow.

SECTION – D (Marks 20)

Note: Attempt any two questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. Explain Ohm's law. What are its limitations?

Ans: **See Q4. (a), Past FBISE Paper (2014), Page # 97.**

b. A current of 3 mA is flowing through a wire for 1 minute. What is the charge flowing through the wire?

Solution: Current $= I = 3\,mA = 3.0 \times 10^{-3}\,A$; Time = t = 1 min. = 60 sec.

Charge = Q = ?

Since $Q = It = 3.0 \times 10^{-3} \times 60 = 180 \times 10^{-3}\,C$

Q.5 a. Explain the energy dissipation in a resistance. What is Joule's law?

Ans: **See Q2. (v), Past FBISE Paper (2019), Page # 127.**

b. The resistance of a conductor wire is 10 $M\Omega$. If a potential difference of 100 volt is applied across its ends, then find the value of current passing through it in mA.

Solution: Resistance = R = 10 M $\Omega = 10 \times 10^6\Omega = 10^7\Omega$; $(1M = 10^6)$

Potential difference = V = 100 Volts = $10^2\,V$; Current $= I = ?$

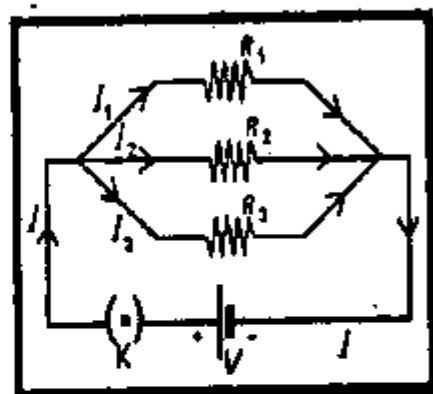
By using ohm's law $V = IR$

$$I = \frac{V}{R} \Rightarrow I = \frac{10^2}{10^7} = 1.0 \times 10^{7-2}\text{A} = 1.0 \times 10^{-5}\,\text{A} = 10^{-2} \times 10^{-3}\,\text{A}$$

Q.6 a. Discuss the main features of parallel combination of resistors.

Ans: Parallel Combination of Resistors:

i. In parallel combination one end of each resistor is connected with positive terminal of battery while the other end of each resistor is connected with the negative terminal of battery. Therefore, the voltage is same across each resistor which is equal to the voltage of the battery i.e.

$$V = V_1 = V_2 = V_3$$

Three resistors in parallel combination

ii. In parallel circuit, the total current equals the sum of the currents in various resistances i.e.,

$$I = I_1 + I_2 + I_3$$

iii. The reciprocal of equivalent resistance $\frac{1}{R_e}$ of the combination is the sum of the reciprocals of the individual resistances. $$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

If resistances $R_1, R_2, R_3, \ldots\ldots R_n$ are connected in parallel then the equivalent resistance of the combination will be given by $$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots\ldots\ldots + \frac{1}{R_n}$$

b. By applying a potential difference of 10 V across a conductor a current of 1.5 A passes through it. How much energy would be obtained from the current in 2 minutes?

Solution: **See Q5., Past FBISE Paper (2018), Page # 123.**

IMPORTANT QUESTIONS & ANSWERS

Q.1 Two resistances of 6 kΩ and 12 kΩ are connected in parallel. A 6V battery is connected across its ends; find the values of the following quantities:

(a) Equivalent resistance of the parallel combination.

(b) Current passing through each of the resistances,

(c) Potential difference across each of the resistance.

Ans. [(a) 4 kΩ, (b) 1 mA, 0.5 mA (c) 6 V]

Solution: Resistances = $R_1 = 6\ K\Omega$,
Resistances = $R_2 = 12\ K\Omega$
Potential = V = 6 Volts

(a) Equivalent resistance = R_e = ?

(b) Current through each resistance = I = ?

(c) Potential difference across each resistance = V = ?

(a) As the resistances are connected in Parallel, therefore equivalent resistance R_e will be

$$\frac{1}{R_e} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\frac{1}{\ } \quad \frac{1}{\ } + \frac{1}{\ } \quad \Rightarrow \quad \frac{1}{\ } = \frac{2+1}{\ }$$

$$\frac{1}{R_e} = \frac{3}{12\,k\Omega} \Rightarrow R_e = \frac{12\,k\Omega}{3} \Rightarrow R_e = 4\,k\Omega$$

(b) The current passing through resistance R_1 will be $V = I_1 R_1$

$$I_1 = \frac{V}{R_1} \Rightarrow I_1 = \frac{6V}{6\,k\Omega} \Rightarrow I_1 = \frac{1}{1000}\,V\Omega^{-1} \Rightarrow I_1 = 0.001\,A$$

$$I_1 = 10^{-3}\,A \Rightarrow I_1 = 1\,mA$$

Similarly, current passing through resistance R_2 will be $V = I_2 R_2$

$$I_2 = \frac{V}{R_2} \Rightarrow I_2 = \frac{6V}{12\,k\Omega} \Rightarrow I_2 = \frac{1}{2000}\,V\Omega^{-1} \Rightarrow I_2 = 0.0005\,A$$

$$I_2 = 0.5 \times 10^{-3}\,A \Rightarrow I_2 = 0.5\,mA$$

(c) As the resistance are in parallel combination so all the resistances at the same potential difference V = 6 Volts of the battery.

Q2. An incandescent light bulb with an operating resistance of 95 Ω is labelled "150 W." Is this bulb designed for use in a 120V circuit or a 220V circuit?

Solution: Resistance = R = 95 Ω ; Power = P = 150 Watts
Voltage = V_1 = 120 V ; Voltage = V_2 = 220 V

By using formula: $P = \frac{V^2}{R}$

(a) For $V_1 \Rightarrow P = \frac{V_1^2}{R} = \frac{(120)^2}{95} = \frac{14400}{95} = 151.58\,W$

(b) For $V_2 \Rightarrow P = \frac{V_2^2}{R} = \frac{(220)^2}{95} = \frac{48400}{95} = 509.47\,W$

Hence the circuit has been designed for 120 V.

Q3. In order to measure voltage in a circuit voltmeter is always connected in parallel Discuss.

Ans: voltmeter is a device used for measuring voltages across a circuit, in order to measure voltages accurately we have to connect it in parallel to the circuit because of the fact that voltage is same in parallel and divides in series so if connected in parallel it will show the exact volt as in circuit but if connected in series the voltages will be the sum of that, drops in circuit and in voltmeter.

Q4. How many watt-hours are there in 1000 joules?

Ans: $1\,k\,wh = 3.6 \times 10^6\,J$

$$1\,wh = \frac{3.6 \times 10^6}{10^3}\,J \Rightarrow 1\,wh = 3.6 \times 10^{6-3}\,J \Rightarrow 1\,wh = 3.6 \times 10^3\,J$$

$$1\,J = 0.000278\,wh \Rightarrow 1000\,J = 0.000278 \times 1000 = 0.27778\text{ watt hour}$$

Q5. From your experience in watching cars on the roads at night, are automobile headlamps connected in series or in parallel?

Ans: Head lamps of auto mobiles are connected in parallel. Because if they were in a serial connection then when one burned out they would both go out, and they can get just as much current as they need.
In parallel wiring if one head lamp is out of order the other lamps still glow. Also we can turn ON or OFF any individual headlamp independently, which is the only possible if they are connected in parallel.

Q6. A certain flash-light can use a 10 ohm bulb or a 5 ohm bulb. Which bulb should be used to get the brighter light? Which bulb will discharge the battery first?

Ans: low resistance means more current which means battery will be discharged quickly.
A bulb of 5 ohm gives brighter light because low resistance gives rise high current. High current and low resistance of 5 ohm bulb will discharge the battery first.

Q7. It is impracticable to connect an electric bulb and an electric heater in series. Why?

hence the power through each appliance. In order to avoid this loss of current, and power ($P = IV$) through bulb and heater, they are connected in parallel.

Q8. Describe briefly the potential difference.

Ans: Potential difference:

Potential difference across the two ends of a conductor causes the dissipation of electrical energy into other forms of energy as charges flow through the circuit.

Unit: SI unit of potential difference is volt.

Volt: In an electric field, the potential between two points is said to be 1V if the amount of work done by 1 Coulomb charge (6.25×10^{18} electrons) in moving from one point to another is one **Joule.**

$$1\,Volt = \frac{Joule}{Coulomb}$$

OR

A potential difference of 1V across a bulb means that each coulomb of charge or 1 ampere of current that passes through the bulb consumes 1 joule of energy.

Q9. If a current of 0.5 A passes through a bulb connected across a battery of 6 V for 20 seconds, then find the rate of energy transferred to the bulb. Also find the resistance of the bulb.

Solution: We have $I = 0.5$ A, $V = 6\,V, t = 20\,s$

Now using the formula,

Energy $W = VIt$ we get, Energy $= 6V \times 0.5\,A \times 20s = 60;$

So the rate of energy transferred must be 60 J in 20 s or 3 Js^{-1} or 3 watt.

Now using, Energy = $W = I^2 Rt$

$$3 = (0.5)^2 \times R \times 20 \Rightarrow R = 3 \times \frac{1}{20} \times \frac{1}{0.25} = \frac{3}{5} = 0.6\,\Omega$$

Q10. State electric power and its unit.

Ans: Electric Power: *The amount of energy supplied by current in unit time is known as electric power.*

$$\text{Electric power} = P = \frac{W}{t} = \frac{QV}{t} = IV = I^2R$$

Unit of Electric Power:

The unit of electric power is watt which is equal to one joule per second ($1\,Js^{-1}$). It is represented by the symbol W.

Q11. The resistance of an electric bulb is 500 Ω. Find the power consumed by the bulb when a potential difference of 250 V is applied across its ends.

Solution: Given that, $R = 500\,\Omega, V = 250\,V$; Using the formula, $I = V/R$

We get, current $I = 250V/500\,\Omega = 0.5A$ and Power $P = I^2R = (0.5A)^2\,500\,\Omega = 125\,W$

Q12. Why electric energy is measured in kilowatt hour.

Ans: Electric energy is commonly consumed in very large quantity for the measurement of which joule is a very small unit. Hence a very large unit of electric energy is needed which is called kilowatt-hour.

Q13. Describe briefly kilowatt hour.

Ans: Kilowatt – Hour:

The amount of energy delivered by a power of one kilowatt in one hour is called kilowatt-hour.

$$One\ kilowatt - hour\ 1\,kWh = 1000\,W \times 1\,hour = 1000W \times (3600\,s)$$

$$= 36 \times 10^5 J = 3.6MJ \quad ; \quad (\because 1Mega = 10^6)$$

The energy in kilowatt-hour can be obtained by the following formula:

$$\text{The amount of energy in kilowatt-hour} = \frac{watt \times time\ of\ use\ in\ hours}{1000}$$

Q14. Calculate the one month cost of using 50 W energy saver for 8 hours daily in your study room. Assume that the price of a unit is Rs.12.

Q15. If 0.5 C charge passes through a wire in $10s$, then what will be the value of current flowing through the wire?

Solution: Given that, $Q = 0.5C$, $t = 10s$,
therefore using $I = Q/t = 0.5C/10s = 0.05A = 50mA$

Q16. Reading on voltmeter connected across a heating element is 60 V. The amount of current passing through the heating element measured by an ammeter is 2 A. What is the resistance of the heating coil of the element?

Solution: Given that, $V = 60V$, $I = 2\,A$.
Ohm's Law $V = IR$

Or $$R = \frac{V}{I} = \frac{60\,V}{2\,A} = 30\,V\,A^{-1} = 30\,\Omega$$

Q17. If the length of copper wire is 1 metre and its diameter is 2 mm. Then find the resistance of this copper wire.

Solution: Given that, length of the wire = $1m$,
Diameter of the wire $d = 2$ mm= 2×10^{-3} m

Cross sectional area of the wire $A = \pi d^2/4 = \frac{3.14 \times (2\times10^{-3})^2\,m^2}{4}$

$$A = 3.14 \times 10^{-6}\,m^2$$

Specific resistance of copper $\rho = 1.69 \times 10^{-8}\,\Omega m$

Now we have $R = \rho \times L/A = 16.69 \times 10^{-8}\,\Omega m \times 1m/3.14 \times 10^{-6}\,m^2$

$R = 0.54 \times 10^{-2}\,\Omega$

Q18. Two resistors of 6 k Ω and 4 k Ω are connected in series across a 10V battery, then find the following quantities:

a. Equivalent resistance of the series combination.
b. The current flowing through each of the resistance.
c. Potential difference across each of the resistances.

Solution:

(a) Given that, $R_1 = 6K\,\Omega\; R_2 = 4\,K\,\Omega$
The equivalent resistance of the series combination is:
$R_e = R_1 + R_2 = 6\,k\Omega + 4\,k\Omega = 10\,k\Omega$

(b) If a battery of 10 V is connected across the equivalent resistance Re, the current passing through it is given by

$$1 = \frac{V}{R_e} = \frac{10V}{10K\Omega} = 1.0 \times 10^{-3}\,A$$

In the case of series combination same current would pass through each resistance. Hence current through R_1 and R_2 would be equal to $1.0 \times 10^{-3}\,A$.

(c) Potential difference across $R_1 = V_1 = IR_1 = 1.0 \times 10^{-3}\,A \times 6\,K\Omega = 6V$
Potential difference across $R_2 = V_2 = IR_2 = 1.0 \times 10^{-3}\,A \times 4K\Omega = 4V$

Q19. If in the circuit shown in Fig. (14.13), $R_1 = 2\Omega, R_2 = 3\Omega, R_3 = 6\,\Omega$, and $V = 6V$, then find the following quantities:

(a) equivalent resistance of the circuit.
(b) current passing through each resistance.
(c) The total current of the circuit.

Solution:

(a) As the resistors are connected in parallel, equivalent resistance R_3 of the combination is give by

Therefore, $R_e = 1\Omega$. This value is smaller than the lowest value of the resistance in the combination which is always the case in parallel circuits.

(b) In parallel combination, the potential difference across each of the resistance is same and is equal to the potential of the battery, which is 6V. Therefore,

Current through $R_1 = I_1 = \frac{V}{R_1} = \frac{6V}{2\Omega} = 3A$

Current through $R_2 = I_2 = \frac{V}{R_2} = \frac{6V}{3\Omega} = 2A$

Current through $R_3 = I_3 = \frac{V}{R_3} = \frac{6V}{6\Omega} = 1A$

(c) Sum of the currents passing through the resistances in parallel combination is equal to the total current I of the circuit. Therefore, total current I is 6 A.

Q20. If a current of 0.5 A passes through a bulb connected across a battery of 6 V for 20 seconds, then find the rate of energy transferred to the bulb. Also find the resistance of the bulb.

Solution: We have $I = 0.5$ A, $V = 6\,V$, $t = 20\,s$

Now using the formula, Energy $W = VIt$

we get, Energy = $6V \times 0.5\,A \times 20s = 60$

So the rate of energy transferred must be 60 J in 20 s or 3 Js^{-1} or 3 watt.

Now using, Energy = $W = I^2 Rt$

We get resistance as

$$3 = (0.5)^2 \times R \times 20$$

$$R = 3 \times \frac{1}{20} \times \frac{1}{0.25} = \frac{3}{5} = 0.6\,\Omega$$

Q21. The resistance of an electric bulb is 500 Ω. Find the power consumed by the bulb when a potential difference of 250 V is applied across its ends.

Solution:

Given that, $R = 500\,\Omega$, $V = 250\,V$

Using the formula, $I = V/R$

We get, current $I = 250V/500\,\Omega = 0.5A$

and Power $P = I^2R = (0.5A)^2\,500\,\Omega = 125\,W$

Q22. Calculate the one month cost of using 50 W energy saver for 8 hours daily in your study room. Assume that the price of a unit is Rs.12.

Solution:

Given that, Power = $50\,W = 0.05\,kW$, time = 8 hours

Number of units consumed = $8 \times 30 \times 0.05 = 12$ units

Therefore, total cost = $12 \times 12 = Rs.\,144$

UNIT 15: ELECTROMAGNETISM

15.1 Magnetics effects of steady current
15.5 Electromagnetic induction
15.6 Direction of induce emf, Lenzs law
15.8 Mutual induction
15.9 Transformer

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 6 BASED ON UNIT # 15 (Reduced Syllabus) ELECTROMAGNETISM

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. Which statement is true about the magnetic poles?
A. unlike poles repel B. like poles attract
C. magnetic poles do not effect each other D. a single magnetic pole does not exist

ii. What is the direction of the magnetic field lines inside a bar magnet?
A. from north pole to south pole B. from south pole to north pole
C. from side to side D. there are no magnetic field lines

iii. The presence of a magnetic field can be detected by a
A. small mass B. stationary positive charge
C. stationary negative charge D. magnetic compass

iv. If the current in a wire which is placed perpendicular to a magnetic field increases, the force on the wire
A. increases B. decreases
C. remains the same D. will be zero

v. The magnetic field produced near the current-carrying conductor is
A. stronger B. weaker C. neutral D. none of above

vi. If we grasp a wire with right hand such that the thumb pointed in the direction of current, then the curling fingers of hand will point the

vii. **The direction of induced e.m.f. in a circuit is in accordance with conservation of**
A. mass B. charge C. momentum D. energy

viii. **The step-up transformer**
A. increases the input current B. increases the input voltage
C. has more turns in the primary D. has less turns in the secondary coil

ix. **The turn ratios of a transformer is 10. It means**
A. $I_s = 10\ I_p$ B. $N_s = N_p / 10$
C. $N_s = 10\ N_p$ D. $V_s = V_p \times 10$

x. **Simple coil placed in a magnet cannot rotate more than**
A. 80° B. 70° C. 75° D. 90°

xi. **In step up transformer;**
A. $V_s > N_s$ B. $V_p > V_p$ C. $V_s > V_p$ D. $V_s > N_p$

xii. **A transformer is designed to convert the voltage from 240 V a.c mains to 12 V, and has 4000 turns on its primary coil. The turns on its secondary coil should be**
A. 200 B. 300 C. 100 D. 400

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet-B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. Demonstrate by an experiment that a magnetic field is produced around a straight current-carrying conductor.

ii. State and explain the rule by which the direction of the lines of force of the magnetic field around a current-carrying conductor can be determined.

iii. You are given an unmarked magnetized steel bar and bar magnet, its north and south ends marked N and S respectively. State how would you determine the polarity at each end of the unmarked bar?

iv. Can a transformer operate on direct current?

v. A conductor wire generates a voltage while moving through a magnetic field. In what direction should the wire be moved, relative to the field to generate the maximum voltage?

vi. Describe a simple experiment to demonstrate that a changing magnetic field can induce e.m.f. in a circuit.

vii. What are the factors which affect the magnitude of the e.m.f. induced in a circuit by a changing magnetic field?

viii. Describe magnetic field of a solenoid.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Discuss Faraday's experiment for the production of e.m.f. in magnetic field.

ii. State Faraday's law of electromagnetic induction.

iii. Discuss the maximum minimum strength of magnetic field.

iv. Suppose someone handed you three similar iron bars and told you one was not magnet but the other two were. How would you find the iron bar that was not magnet?

v. Suppose you have a coil of wire and a bar magnet. Describe how you could use them to generate an electric current.

vi. If a transformer is used to supply voltage to a 24 V model train which draws a current 1.6 A. Calculate the current in the primary if the voltage of the a.c. source is 240 V.

vii. Suppose we hang a loop of wire so that it can swing easily. If we now put a magnet into

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. (2 × 10 = 20)

Q.4 a. What do you understand by the term mutual induction?

b. A transformer is needed to convert a mains 240 V supply into a 12 V supply. If there are 2000 turns on the primary coil, then find the number of turns on the secondary coil.

Q.5 a. Describe the direction of an induced e.m.f. in a circuit? How does this phenomena relate to conservation of energy?

b. A step-up transformer has a turn ratios of 1:100. An alternating supply of 20 V is connected across the primary coil. What is the secondary voltage?

Q.6 a. What is a transformer? Explain the working of transformer in connection with mutual induction.

b. A step-down transformer has a turns ratio of 100:1. An ac voltage of amplitude 170 V is applied to the primary. If the current in the primary is 1.0 mA, what is the current in the secondary?

Solution of Guess Paper & Model Paper # 6 (Reduced Syllabus)

SECTION- A (MCQs)

i. D	ii. B	iii. D	iv. A	v. A	vi. C
vii. D	viii. B	ix. D	x. D	xi. C	xii. A

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. Demonstrate by an experiment that a magnetic field is produced around a straight current-carrying conductor.

Ans. Demonstration for magnetic field is produced around straight current carrying conductor (wire).

ii. State and explain the rule by which the direction of the lines of force of the magnetic field around a current-carrying conductor can be determined.

Ans: See Q2. (vi), Past FBISE Paper (2019), Page # 127.

iii. You are given an unmarked magnetized steel bar and bar magnet, its north and south ends marked N and S respectively. State how would you determine the polarity at each end of the unmarked bar?

Ans: Suspend the unmarked bar magnet by a thread from its centre. Bring the north pole of marked bar magnet near one end of suspended magnet. Repulsion will show that this end is north pole of unmarked bar magnet. Attraction will show its south pole.

iv. Can a transformer operate on direct current?

Ans: No, a transformer can not operate on direct current.

The primary coil has to induce current in the secondary coil. The only way this can happen is if there is a varying magnetic field in the primary which then will induce a varying magnetic field in the secondary which results in a current in the sec.

v. A conductor wire generates a voltage while moving through a magnetic field. In what direction should the wire be moved, relative to the field to generate the maximum voltage?

Ans: When we place a conductor wire in a magnetic field then it will experience a magnetic force in the direction

vi. Describe a simple experiment to demonstrate that a changing magnetic field can induce e.m.f. in a circuit.

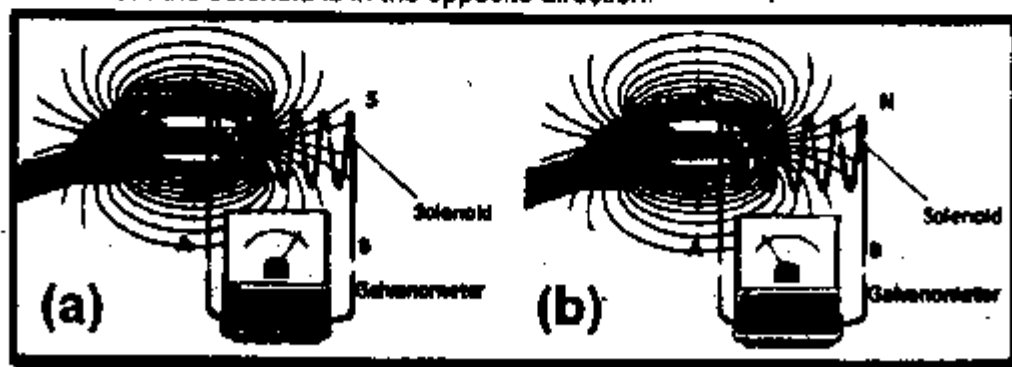
Ans: Electromagnetic Induction:

The process of generating an induced current in a circuit by changing the number of magnetic lines of force passing through it is called electromagnetic induction.

Experiment:

Figure shows one of Faraday's experiments in which current is induced by moving a magnet into the solenoid or out of the solenoid.

When the magnet is stationary, no current is induced. When the magnet is moved towards the solenoid, the needle of galvanometer deflects towards right, indicating that a current is being induced in the solenoid.

When the magnet is pulled away from the solenoid, the galvanometer deflects towards left, indicating that the induced current in the solenoid is in the opposite direction.

Phenomenon of electromagnetic induction by the movement of a magnet through solenoid.
(a) Magnet moves towards the stationary solenoid. (b) Magnet moves away from the stationary solenoid

Conclusion:

From the above experiments, we conclude that an e.m.f. is induced in the coil when there is a relative motion between the coil and the magnet. This phenomenon in which an e.m.f. is induced due to the relative motion between the coil and the magnet is called electromagnetic induction.

vii. What are the factors which affect the magnitude of the e.m.f. induced in a circuit by a changing magnetic field?

Ans: Factors Affecting Induced e.m.f

The magnitude of induced e.m.f. in a circuit depends on the following factors:

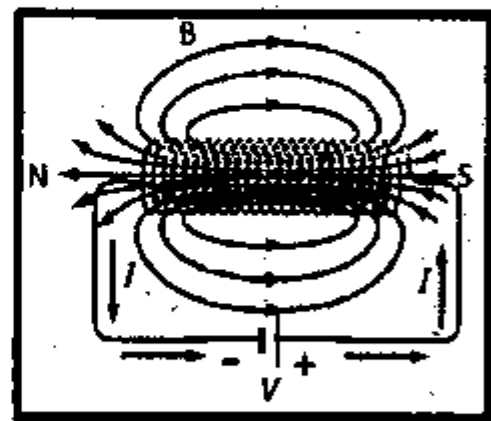
i. Speed of relative motion of the coil and the magnet.
ii. Number of turns of the coil.
iii. Amount of current passing through the coil.

viii. Describe magnetic field of a solenoid.

Ans: Solenoid: A long coil of wire consisting of many loops is called a solenoid.

Magnetic Field of a Solenoid:

The field from each loop in a solenoid adds to the fields of the other loops and creates greater total field strength. Electric current in the coil of wire produces magnetic field which is similar to the magnetic field of a permanent magnet. When this current-carrying coil is brought close to a suspended bar magnet, one end of the coil repels the north pole of the magnet. Thus, the current-carrying coil has a north and a south pole and is itself a magnet.

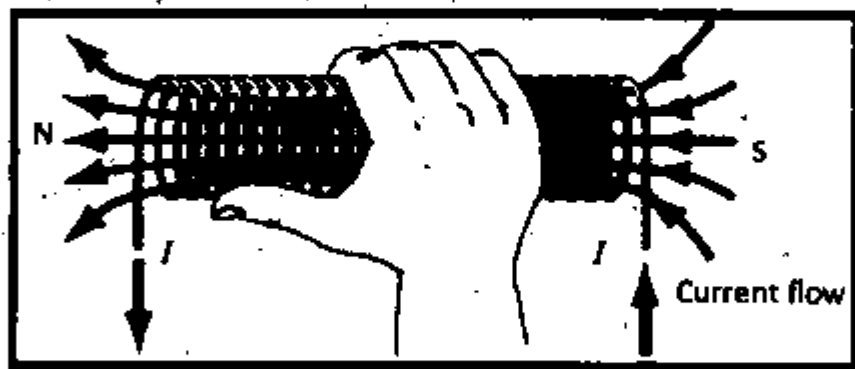
Magnetic field due to a solenoid

Electromagnet:

The type of temporary magnet, which is created when current flows through a coil, is called an

Direction of the Field:

The direction of the field produced by a coil due to the flow of conventional current can be found with the help o Right hand grip rule stated as;

Right Hand Grip Rule:

If we grip the coil with our right hand by curling our fingers in the direction of the conventional current, our thumb will indicate the north pole of the coil.

Right hand grip rule for a coil

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Discuss Faraday's experiment for the production of e.m.f. in magnetic field.

Ans: Experiment:

Take a rectangular loop of wire and connect its two ends with a galvanometer. Now hold the wire stationary or move it parallel to the magnetic field of a strong u-shaped magnet. Galvanometer shows no deflection and hence there is no current. Now move the wire downward through the field, current is induced in one direction as shown by the deflection of the galvanometer (Fig-a). Now move the wire upward through the field, current is induced in the opposite direction (Fig-b).

Demonstration of electromagnetic induction by the movement of a wire loop in the magnet field

It implies that an electric current is generated in a wire only when the wire cuts magnetic field lines. This induced current is generated by the induced e.m.f. in the circuit.

ii. State Faraday's law of electromagnetic induction.

Ans: Faraday's law of electromagnetic induction:

The value of induced e.m.f. in a circuit is directly proportional to the rate of change of number of magnetic lines of force through it.

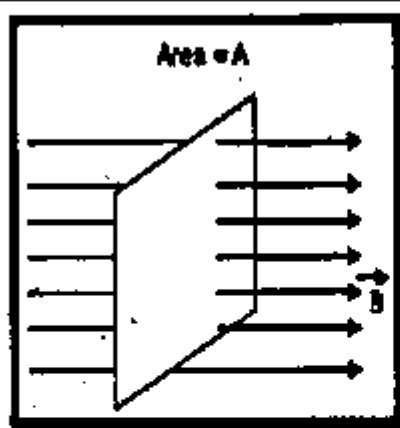
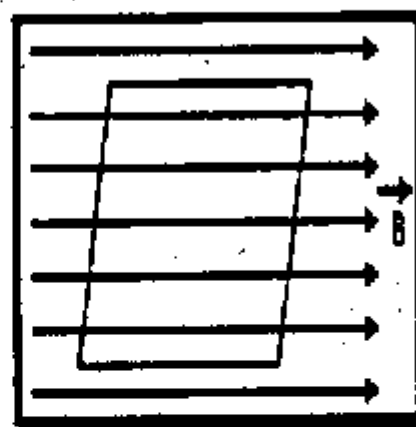
This is called Faraday's law of electromagnetic induction.

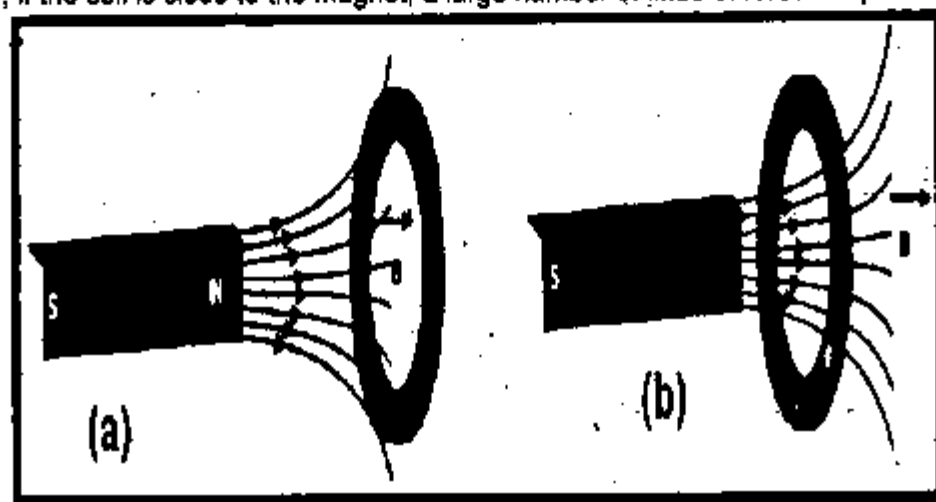
iii. Discuss the maximum minimum strength of magnetic field.

Ans: Strength of Magnetic Field:

The strength of magnetic field is defined as the number of magnetic lines of force passing through any surface.

The number of lines of force is maximum when the surface is held perpendicular to the magnetic lines of force.

It will be minimum when surface is held parallel to the magnetic lines of force. If we place a coil in the magnetic field of a bar magnet, some of the magnetic lines of force will pass through it.

Maximum strength of magnetic field

Minimum strength of magnetic field

If the coil is far away from the magnet, only a few lines of force will pass the coil.
However, if the coil is close to the magnet, a large number of lines of force will pass through it.

Variation of magnetic field lines of force through a coil placed at different distances from the magnet

This means, we can change the number of magnetic lines of force through a coil by moving it in the magnetic field. This change in the number of magnetic field lines will induce an e.m.f. in the coil.

This is the basic principle of production of electricity and working of transformer.

iv. Suppose someone handed you three similar iron bars and told you one was not magnet but the other two were. How would you find the iron bar that was not magnet?

Ans: We will place compass needle near these three iron bar. The compass needle will show response near magnet. So when we take compass needle near the iron bar and if this compass needle did not change its direction then this means that this iron bar is not a magnet.

v. Suppose you have a coil of wire and a bar magnet. Describe how you could use them to generate an electric current.

Ans: We will move the bar magnet into and out of the coil and this changing magnetic field will induce emf and electric current.

vi. If a transformer is used to supply voltage to a 24 V model train which draws a current 1.6A. Calculate the current in the primary if the voltage of the a.c. source is 240 V.

Solution: Given that, $V_p = 240\,V$

$V_s = 12\,V$

$I_s = 0.8\,A$

$I_p = ?$

By law of conservation of energy,

Input power of the primary = Out power of the secondary

Therefore, $I_p = \frac{I_s V_s}{V_p}$ $I_p = \frac{(12\,V)(0.8\,A)}{240\,V} = 0.04$ A

vii. Suppose we hang a loop of wire so that it can swing easily. If we now put a magnet into the coil, the coil will start swinging. Which way will it swing relative to the magnet and why?

Ans: It is according to the law of electromagnetic induction; Lenz's law, states that the direction of the induced e.m.f is always such as to oppose the change producing it. Therefore coil will swinging relative to the magnet.

SECTION – D (Marks 20)

Note: Attempt any two questions. All questions carry equal marks. **(2 × 10 = 20)**

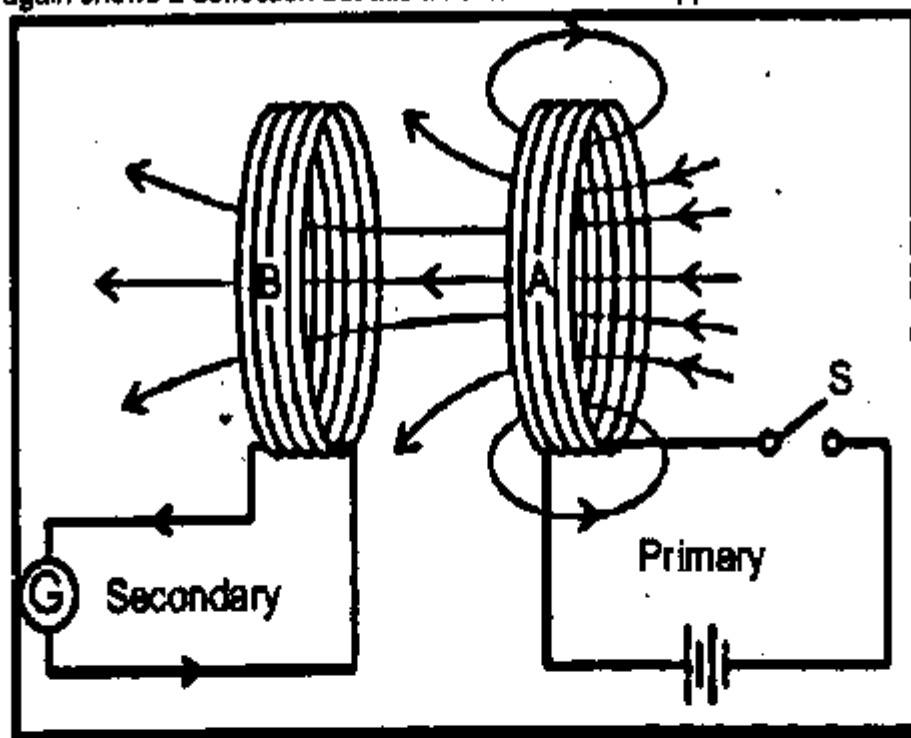
Q.4 What do you understand by the term mutual induction?

Ans: Mutual Induction:

The phenomenon of production of induced current in one coil due to change of current in a neighboring coil is called mutual induction.

Primary and secondary coil:

The coil in which the change in current produces induced current in another coil is known as primary coil and the coil in which current is induced is known as a secondary coil.

Suppose a system of two coils A and B placed close to each other. The coil A is connected to a battery and a switch, while a sensitive galvanometer is connected to the coil B. We observe that as soon as the switch of the coil A is closed, the galvanometer shows a momentary deflection. Similarly when the switch is opened the galvanometer again shows a deflection but this time its direction is opposite to that of the previous case.

Mutual Induction

Explanation:

We can explain these observations using Faraday's law of electromagnetic induction. When the switch of coil A is closed, a current is induced in the coil due to which magnetic field is developed across the coil.

Some of the magnetic lines of force of this field start passing through the coil B. Since current is changing in the coil A, hence number of magnetic lines of force across the coil B also changes due to which a current is induced in the coil B in accordance with Faraday's law.

When current in the coil A becomes steady, number of magnetic lines of force across the coil A also become constant. Therefore, there is no more change in number of magnetic lines of force through the coil B due to which induced current in coil B reduces to zero.

b. A transformer is needed to convert a mains 240 V supply into a 12 V supply. I there are 2000 turns on the primary coil, then find the number of turns on th secondary coil.

Solution: Voltage across primary $V_p = 240$ volts

Voltage across secondary $V_s = 12$ volts

Number of turns of primary coil $N_p = 200$

Number of turns of secondary coil $N_s = ?$

Since, $$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow N_s = \frac{V_s}{V_p} \times N_p = \frac{12}{240} \times 200 = 100 \text{ turns}$$

Q.5 a. Describe the direction of an induced e.m.f. in a circuit? How does this phenomen relate to conservation of energy?

Ans: Direction of induced e.m.f.

Lenz's Law:

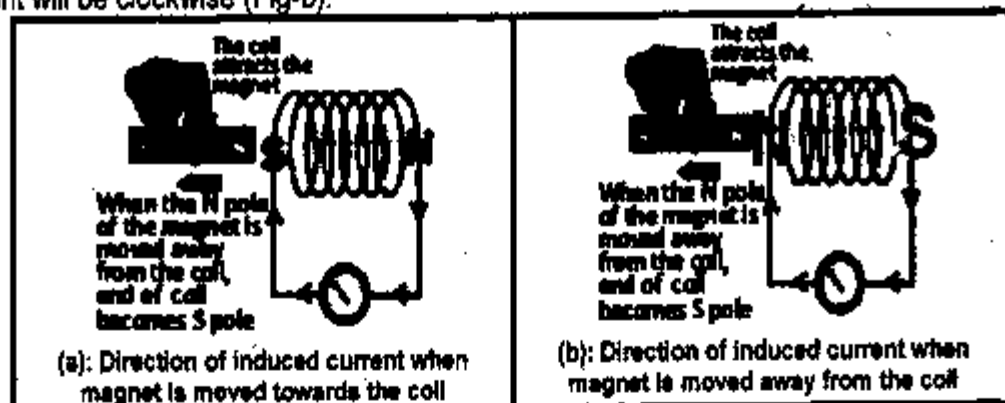
The direction of an induced current in a circuit is always such that it opposes the cause that produces it

Experiment:

If we bring a north pole of a bar magnet near a solenoid, an e.m.f. will be induced in the solenoid by electromagnetic induction (Fig-a). The direction of the induced current in the solenoid by the induced e.m.f. wil be such that it will repel the north pole of the magnet. This is only possible if the right end of the solenoi becomes a north pole. Hence, according to right hand grip rule, the direction of the induced current in the solenoid will be anticlockwise.

Similarly, when we move the north pole of the magnet away from the solenoid, the direction of the induced current will be clockwise (Fig-b).

(a): Direction of induced current when magnet is moved towards the coil

(b): Direction of induced current when magnet is moved away from the coil

Lenz's law is a manifestation of the law of conservation of energy:

If we apply the law of conservation of energy to electromagnetic induction, we realize that the electrica energy induced in a conductor appears from the kinetic energy of the moving magnet. We do some work or the magnet to bring it close to the solenoid. This work done consequently appears as electrical energy in the conductor.

Thus mechanical energy of our hand used to push the magnet towards or away from the coil results into electrical energy. Hence Lenz's law is a manifestation of the law of conservation of energy.

b. A step-up transformer has a turn ratios of 1:100. An alternating supply of 20 V is connected across the primary coil. What is the secondary voltage?

Solution: In case of step-up transformer

Turn ratio is 1:100 $\Rightarrow$ $N_p : N_s = 1:100 = \frac{N_p}{N_s} = \frac{1}{100}$

Voltage across primary $V_p = 20$ volts.

Voltage across secondary coil $V_s = ?$

Since, $$\frac{V_s}{V_p} = \frac{N_s}{N_p} \Rightarrow V_s = 100 \times 20 = 2000 \text{ volts}$$

Q.6 a. What is a transformer? Explain the working of transformer in connection with mutual induction.

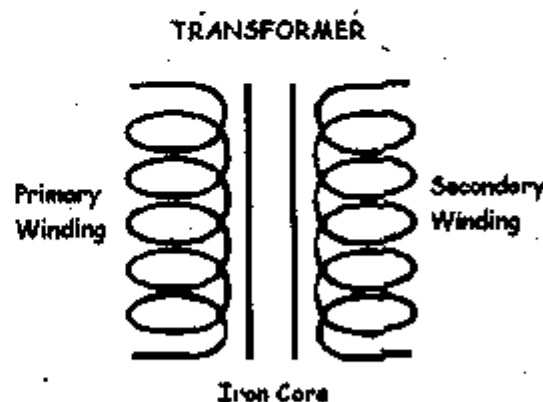
Ans: Transformer:

This is an electrical device which is used to increase or decrease the value of alternating voltage.

Principle of Transformer: Transformer works on the principle of mutual induction.

Symbol for transformer:

Construction of Transformer:

Transfer consists of two coils which are wound on two different sides of a rectangular iron core. One coil is called primary and the second one is known as secondary.

Working of a transformer:

Primary and Secondary Coils:

A transformer has two coils, electrically insulated from each other, but wound around the same iron core. One coil is called the primary coil. The other coil is called the secondary coil.

Number of turns on the primary and the secondary coils are represented by N_p and N_s respectively. When the primary coil is connected to a source of A.C. voltage, the changing current creates a changing magnetic field, which is carried through the core to the secondary coil. In the secondary coil, the changing field induces a varying e.m.f. This effect is called mutual inductance.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

Types of Transformer:

Step-Up Transformer:

If the secondary voltage is larger than the primary voltage, the transformer is called a step-up transformer.

Step-Down Transformer:

If the secondary voltage is smaller than the primary voltage, the transformer is called a step-down transformer.

b. A step-down transformer has a turns ratio of 100:1. An ac voltage of amplitude 170 V is applied to the primary. If the current in the primary is 1.0 mA, what is the current in the secondary?

Solution: In case of step-down transformer

Turn ratio is 1:100 $\Rightarrow$ $N_s : N_p = 1 : 100$

$$\frac{N_s}{N_p} = \frac{1}{100}$$

Voltage across primary $V_p = 170$ volts.

Current across primary $I_p = 1.0\,\text{mA} = 1.0 \times 10^{-3}\,\text{A}$

Current across secondary coil $I_s = ?$

Since, $I_s = I_p \times \frac{N_P}{N_S} = 1.0 \times 10^{-3} \times \frac{100}{1} = \frac{1}{1000} \times \frac{100}{1}$

UNIT 16: BASIC ELECTRONICS

16.1 Thermionic emission
16.2 Investigating the properties of electron
16.4 Analog and Digital electronics
16.5 Basic operation of digital electronics
16.6 - 16.10 All Logic gates

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 7
BASED ON UNIT # 16 (R[illegible]ed Syllabus)
BASIC ELECTRONICS

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. The process by which electrons are emitted by a hot metal surface is known as
A. boiling B. evaporation C. conduction D. thermionic emission

ii. In AND operation if any one of logic input is at '0' then output is
A. 1 B. 2 C. 4 D. 0

iii. The logical operation performed by this gate is
A. AND B. NOR C. NAND D. OR

iv. AND gate can be formed by using two
A. NOT gates B. OR gates C. NOR gates D. NAND gates

v. The output of a two-input NOR gate is 1 when:
A. A is 1 and B is 0 B. A is 0 and B is 1
C. both A and B are 0 D. both A and B are 1

vi. If $X = A.B$, then X is 1 when:
A. A and B are 1 B. A or B is 0
C. A is 0 and B is 1 D. A is 1and B is 0

vii. The output of a NAND gate is 0 when

viii. The screen of a cathode ray tube consist of thin layer of ;
A. aluminum B. Potassium C. sulphur D. Phosphor

ix. The electronic circuit which implements the OR operation is;
A. NOR gate B. AND gate C. OR gate D. NAND gate

x. The output of NAND is written as;
A. $x = A + B$ B. $x = A - B$ C. $x = A \cdot B$ D. $x = \overline{A \cdot B}$

xi. To make burglar alarm, we use;
A. NAND gate B. And Gate C. OR gate D. NOT gate

xii. Which representing data using 1s or 0s?
A. bit B. byte C. kilobyte D. mega byte

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet–B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. Describe, using one simple diagram in each case, what happens when a narrow beam of electrons is passed through A. a uniform electric field B. a uniform magnetic field. What do these results indicate about the charge on electron?

ii. Differentiate between analogue electronics and digital electronics. Write down names of five analogue and five digital devices that are commonly used everyday life.

iii. State and explain for each case whether the information given by the following devices is in analogue or a digital form.
   a. a moving-coil voltmeter measuring the e.m.f of a cell.
   b. a microphone generating an electric current.
   c. a central heating thermostat controlling the water pump.
   d. automatic traffic lights controlling the flow of traffic.

iv. Write down some benefits of using digital electronics over analogue electronics.

v. Name two factors which can enhance (increase) thermionic emission.

vi. Give three reasons to support the evidence that cathode rays are negatively charged electrons.

vii. When electrons pass through two parallel plates having opposite charges they are deflected towards the positively charged plate. What important characteristic of the electron can be inferred from this?

viii. When a moving electron enters the magnetic field, it is deflected from its straight path. Name two factors which can enhance electron deflection.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. How can you compare the logic operation $X = A.B$ with usual operation of multiplication.

ii. NAND gate is the reciprocal of AND gate. Discuss

iii. Show that the circuit given as below acts as OR gate.

iv. Show that the circuit given as below acts as AND gate.

v. What is truth table?

vi. What do you understand by analogue to digital converter (ADC)?

vii. What do you understand by digital to analogue converter (DAC)?

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. (2 × 10 = 20)

Q.4 a. Differentiate between digital and analog electronics.

Q.5 a. What are the three universal Logic Gates? Give their symbols and truth tables.

b. Assume you have an OR gate with two inputs, A and B.
Determine the output, C, for the following cases:
A. A = 1, B = 0
B. A = 0, B = 1
If either input is one, what is the output?

Q.6 a. Describe NAND and NOR gate and draw its symbol and truth table?
b. What is Boolean algebra and Boolean constants?

Solution of Guess Paper & Model Paper # 7
(Reduced Syllabus)

SECTION- A (MCQs)

i. D	ii. D	iii. C	iv. D	v. C	vi. A
vii. B	viii. D	ix. A	x. D	xi. C	xii. A

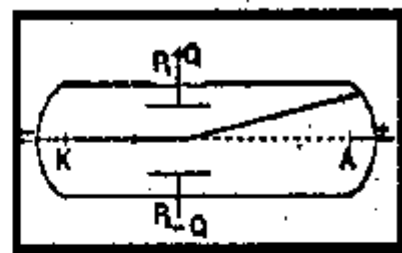
SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. Describe, using one simple diagram in each case, what happens when a narrow beam of electrons is passed through A. a uniform electric field B. a uniform magnetic field. What do these results indicate about the charge on electron?

Ans: Deflection of electrons by a uniform electric field:

We can set up electric field by applying a potential difference across two parallel metal plates placed horizontally separated with some distance. When an electron beam passes between the two plates, it can be seen that the electrons are deflected towards the positive plate. The reason for this is that electrons are attracted by the positive charges and repelled by the negative charges due to force $F = qE$, where q is the electron charge and E is the electric field due to plates. The degree of deflection of electrons from their original direction is proportional to the strength of the electric field applied.

Result: This shows that electrons are negatively charged.

Deflection of Cathode Rays by an electric field

Deflection of electrons by uniform magnetic field:

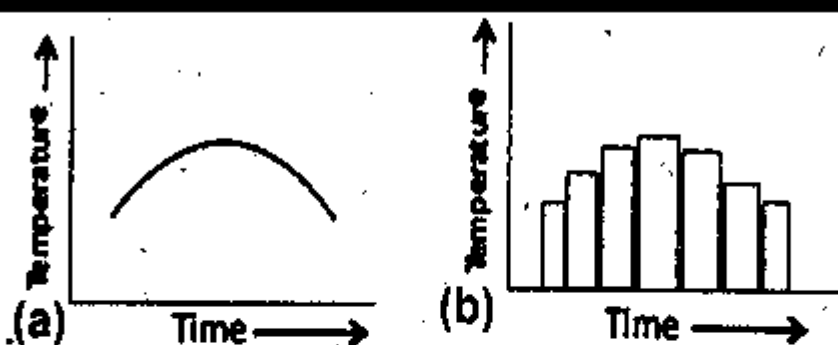
Now we apply magnetic field at right angle to the beam of electrons by using a horse shoe magnet. We will notice that the spot of the electrons beam on screen is getting deflected from its original direction.

Now change the direction of the horse shoe magnet. We will see that spot on the fluorescent screen is getting deflected in the opposite direction.

Result: This shows that electrons are negatively charged.

Deflection of Cathode Rays by a magnetic field

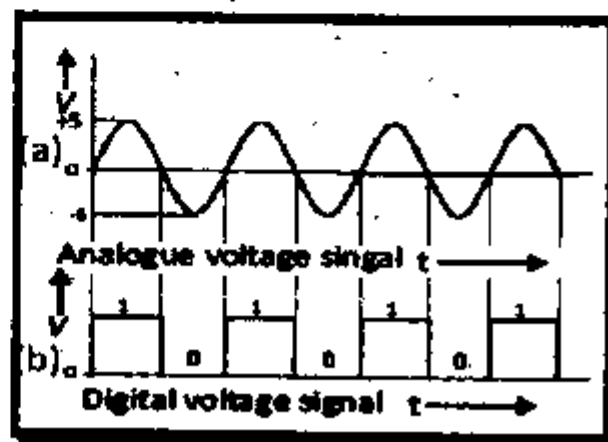
ii. Differentiate between analogue electronics and digital electronics. Write down names of five analogue and five digital devices that are commonly used everyday life.

Ans: Analogue Electronics:

An analogue signal

Digital Electronics:

The branch of electronics which deals with digital quantities is called digital electronics.

Digital quantities are expressed in the form of digits or numbers. Digital electronics uses only two digits 0 (zero) and 1 (one) and the whole data are provided in binary from due to which processing of data becomes easy.

Devices: The devices based upon digital physical electronics are computer, TV, security system, mobile phone, digital camera radar system, naval system, medical equipments etc.

iii. State and explain for each case whether the information given by the following devices is in analogue or a digital form.

a. a moving-coil voltmeter measuring the e.m.f of a cell.
b. a microphone generating an electric current.
c. a central heating thermostat controlling the water pump.
d. automatic traffic lights controlling the flow of traffic.

Ans: a. a moving-coil voltmeter measuring the e.m.f of a cell.

It is analog device which measure the value of emf a cell. The deflection of the moving-coil is continuous variation with time. It is analogue signal.

b. a microphone generating an electric current.

The current in the microphone varies according to the variation in sound pressure. Since this variation is continues, hence current from microphone is an analogue quantity.

c. a central heating thermostat controlling the water pump.

The thermostat depends upon the atmospheric temperature which varies continuously with time. It is an analogue signal. So the thermostat controlling is an analogue device.

d. automatic traffic lights controlling the flow of traffic.

The digital circuit used in traffic control light system makes them ON (1) or OFF (0). Hence, automatic traffic lights is a digital system.

iv. Write down some benefits of using digital electronics over analogue electronics.

Ans: Digital information has certain properties that distinguish it from analog communication methods. These include

- **Synchronization** – digital communication uses specific synchronization (Organization) sequences for determining synchronization.
- **Language** – digital communications requires a language which should be possessed by both sender and receiver and should specify meaning of symbol sequences.
- **Errors** – disturbances in analog communication causes errors in actual intent ...

- **Copying** – analog communication copies are quality wise not as good as their originals while due to error free digital communication, copies can be made indefinitely.
- **Granularity** – for a continuously variable analog value to be represented in digital form there occur quantization error which is difference in actual analog value and digital representation and this property of digital communication is known as granularity.

v. Name two factors which can enhance (increase) thermionic emission.

Ans: **i)** Nature of the metal **ii)** Surface area of the metal

By increasing the temperature and surface area of the cathode, rate of thermionic emission can enhance (increase).

vi. Give three reasons to support the evidence that cathode rays are negatively charged electrons.

Ans: **i)** When cathode rays are created then they move towards the anode of the discharge tube which shows that they are negatively charges.

ii) When an electric field is applied in the discharge tube then cathode rays experiences an attractive force toward the positive plate of the applied electric field which also shows that they have negative charge.

iii) They are deflected in a magnetic field opposite to the direction of positive charge.

vii. When electrons pass through two parallel plates having opposite charges they are deflected towards the positively charged plate. What important characteristic of the electron can be inferred from this?

Ans: This shows that electrons have negative charge.

viii. When a moving electron enters the magnetic field, it is deflected from its straight path. Name two factors which can enhance electron deflection.

Ans: Strength of magnetic field and speed of electron enhance electron deflection. If we increase the angle between velocity of electron within range 0^0 to 90^0 then it will enhance the deflection of electron because magnetic force is equal to $F = qvB\sin\theta$. If we increase the strength of magnetic field then it will enhance the deflection of electron.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. How can you compare the logic operation $X = A.B$ with usual operation of multiplication.

Ans: If we want to compare the logic operation with usual operation of multiplication, we will find same result as in logic operations with same inputs but if the inputs changes from 0 and 1 the logic operation will failed to give result.

ii. NAND gate is the reciprocal of AND gate. Discuss

Ans: The combination of AND gate with NOT gate is called NAND gate. In NAND gate the output of AND gate is inverted. Therefore NAND gate is the reciprocal of AND gate.

iii. Show that the circuit given as below acts as OR gate.

Ans: The given circuit acts as OR gate because in this circuit the output terminal of NOR gate is coupled with NOT operation. In NOR gate the value of OR gate is inverted then followed by NOT operation the value of OR gate is regenerated.

iv. Show that the circuit given as below acts as AND gate.

Ans: In this circuit two NOT operations are working as inputs terminals of NOR gate. Therefore this circuit will act as AND gate.

v. What is truth table?

i. **What do you understand by analogue to digital converter (ADC)?**

ns: Analogue to Digital Converter (ADC):

In our daily life, the quantities that we perceive by our senses are usually analogue quantities which

ns: Digital to Analogue Converter (DAC):

The output of the computer is again converted into an analogue form by a circuit known as digital to analogue converter (DAC). As the output of DAC is an analogue signal, it can be readily sensed by us. Thus, electronic systems used at present consist of both analogue and digital type circuits

SECTION – D (Marks 20)

Note: Attempt any TWO questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. Differentiate between digital and analog electronics.

Ans: Difference between digital and analog electronics:

	Analog	**Digital**
Signal	Analog signal is a continuous signal which represents physical measurements.	Digital signals are discrete time signals generated by digital modulation.
Waves	Denoted by sine waves	Denoted by square waves
Representation	Uses continuous range of values to represent information	Uses discrete or discontinuous values to represent information
Example	Human voice in air, analog electronic devices	Computers, CDs, DVDs, and other digital electronic devices.
Technology	Analog technology records waveforms as they are.	Samples analog waveforms into a limited set of numbers and records them.
Data transmissions	Subjected to deterioration by noise during transmission and write/read cycle.	Can be noise-immune without deterioration during transmission and write/read cycle.
Response to Noise	More likely to get affected reducing accuracy	Less affected since noise response are analog in nature
Flexibility	Analog hardware is not flexible.	Digital hardware is flexible in implementation.

b. What do you understand by digital and analogue quantities?

Ans: Digital Quantities: The quantities which change in non discrete steps are called digital quantities.

Examples:

Modern telephone system, radar system, naval and other systems of military importance, devices to control the operation of industrial machines, medical equipments and many household appliances are using digital technology.

Analogue Quantities: The quantities which change continuously with time are known as analogue quantities.

Examples: Temperature, time, pressure, current, voltage and distance etc., are analogue quantities.

Q.5 a. What are the three universal Logic Gates? Give their symbols and truth tables.

Ans: Three universal Logic Gates:

i. AND Operation:

AND operation is physical realization of the logical Multiplication. It is the implement of AND gate.

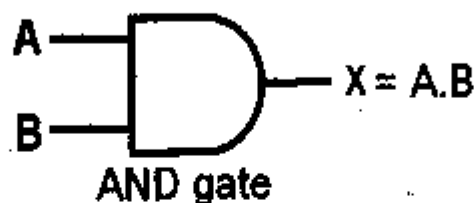
A	B	X = A.B
0	0	$0.0 = 0$
1	0	$1.0 = 0$
0	1	$0.1 = 0$

AND Gate:

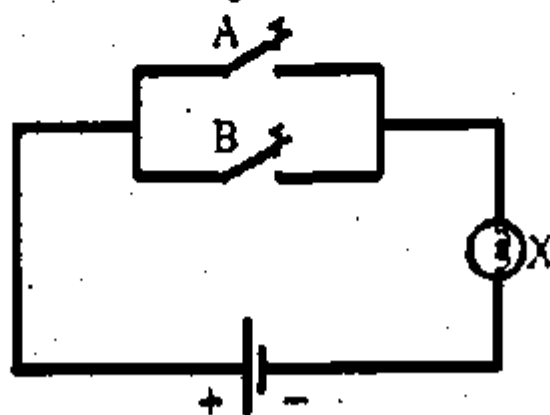
AND Gate is physical realization of the logical multiplication. It is the implement of AND operation.

Symbol of AND Gate:

A, B — X = A.B

AND gate

Note: The output is high only if input X and input Y are high.

ii. **OR operation:**

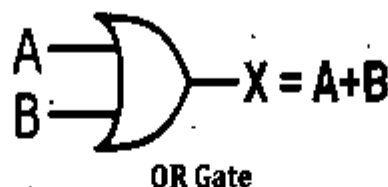
OR operation is physical realization of the logical addition. It is the implement of OR gate.

A	B	X = A + B
0	0	0 + 0 = 0
1	0	1 + 0 = 0
0	1	0 + 1 = 0
1	1	1 + 1 = 1

OR Gate:

OR Gate is physical realization of the logical addition. It is the implement of OR operation.

Symbol of OR gate:

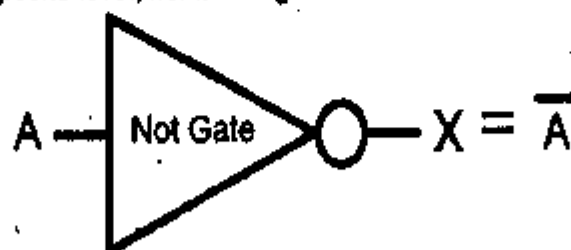
A, B — X = A+B

OR Gate

Note: The output is high when either X or Y or both are high.

iii. **NOT Operation:**

NOT operation is physical realization of the complementation operation.

Function of NOT operation:

It is perform the operation of inversion or complementation. That is why it is also known as inverter. It changes a logical level to its opposite level, i.e. it changes 1 to 0 and 0 to 1.

NOT gate

Truth table:

A	Output = X = $\bar{A}$
0	$\bar{0} = 1$
1	$\bar{1} = 0$

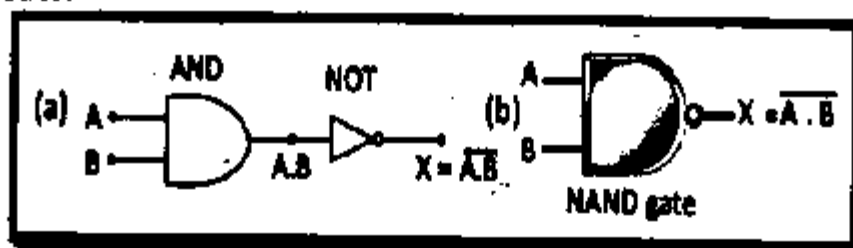
Note: The output is high if the input is not high. The output is always the opposite of the input. It is an inverter.

b. Assume you have an OR gate with two inputs, A and B.
Determine the output, C, for the following cases:
A. A = 1, B = 0
B. A = 0, B = 1
If either input is one, what is the output?

Ans: The value of output of OR gate will be '1' when one of its inputs is at 1. The output will be '0', when both inputs are at '0'.
In both given cases A. and B. the value of output will be 1.
1 + 0 = 1 and 0 + 1 = 1 also 1 + 1 = 1
If either input is one then output is one.

Q.6 Describe NAND and NOR gate and draw its symbol and truth table?

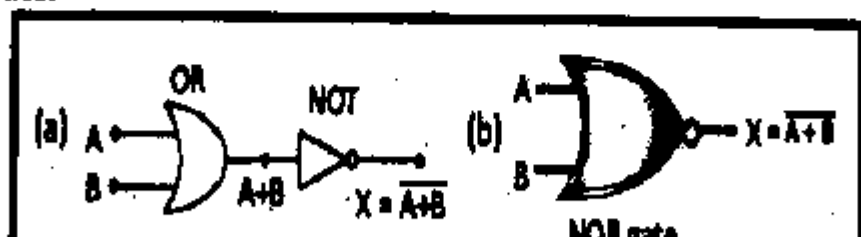
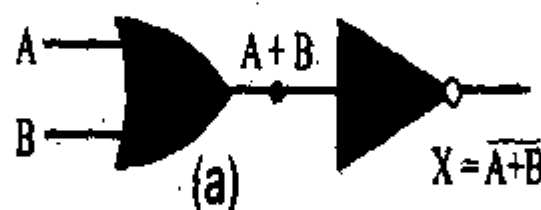
Ans: NAND gate:
The combination of And gate with NOT gate is called NAND gate.
In NAND gate the output of AND gate is inverted. The bubble in this figure shows that the output of AND gate is inverted.

Symbol of NAND Gate:

Truth table for NAND Gate:

A	B	A.B	Out put = X = $\overline{A.B}$
0	0	0.0 = 0	$\bar{0} = 1$
0	1	0.1 = 0	$\bar{0} = 1$
1	0	1.0 = 0	$\bar{0} = 1$
1	1	1.1 = 1	$\bar{1} = 0$

Note: The output is not high only if the input X and input Y are high.

NOR Gate:
The combination of OR gate with NOT gate is called NOR gate.
In NOR gate the output of OR gate is inverted.

Symbol of NOR Gate:

A	B	A + B	Out put = X = $\overline{A+B}$
0	0	0 + 0 = 0	$\overline{0} = 1$
0	1	0 + 1 = 0	$\overline{0} = 0$
1	0	1 + 0 = 0	$\overline{0} = 0$
1	1	1 + 1 = 1	$\overline{1} = 0$

In NOR gate the output of OR gate is coupled with a NOT gate. This NOT gate inverts the output $\overline{A + B}$ of the OR gate, i.e., the output of the NOR gate is $\overline{A + B}$ which is expressed by the following equation $X = \overline{A + B}$

Note: The output is not high if either input X or input Y are high.

b. What is Boolean algebra and Boolean constants ?

Ans: Boolean Algebra:

George Boole invented a special algebra called Boolean algebra also known algebra of logics. It is a branch of mathematics which deals the relationships of logic variables.

Boolean algebra handles variables that represent types of logic propositions: 'true' and 'false'.

Boolean constants:

In Boolean algebra a set of constants has only two elements 0 or 1. Thus a Boolean constant is either 0 if not 1 or is 1 if not 0.

Note: The potential of the output is either 'HIGH' (5 - 6V)' or 'LOW (0 V)'.

IMPORTANT QUESTIONS & ANSWERS

Q1. When a magnet is brought near to the screen of a television tube, picture on the screen is distorted. Do you know why?

Ans: A magnet distorts the picture as it distorts the path of electrons flowing from the electron gun towards the screen inside the television. As electrons are negatively charged particles, their motion is distorted by a magnet. Therefore the picture on the screen is distorted.

Q2. Name any five devices based upon digital physical quantities?

Ans: The devices based upon digital physical electronics are computer, TV, security system, mobile phone, digital camera radar system, naval system, medical equipments etc.

UNIT 18: ATOMIC AND NUCLEAR PHYSICS

18.1 - 18.9 (all theory topics)

NOTE:

- All conceptual questions and side information are excluded.
- Only topic based related MCQs, Short and Long Questions and numerical are included.

GUESS PAPER & MODEL PAPER # 9
BASED ON Unit # 18 (Reduced Syllabus)
ATOMIC AND NUCLEAR PHYSICS

SECTION-A

Time allowed: 20 Minutes **Marks: 12**

Note: Section-A is compulsory. All parts of this section are to be answered on the question paper itself. It should be completed in the first 20 minutes and handed over to the Centre Superintendent. Deleting/overwriting is not allowed. Do not use lead pencil.

Q.1 Encircle the correct option i.e. A / B / C / D. All parts carry equal marks.

i. Isotopes are atoms of same element with different
A. atomic mass B. atomic number
C. Number of protons D. number of electrons

ii. One of the isotopes of uranium is $^{238}_{92}U$. The number of neutrons in this isotope is
A. 92 B. 146 C. 238 D. 330

iii. Which among the following radiations has more penetrating power?
A. A beta particle B. a gamma ray
C. An alpha particle D. All have the same penetrating ability

iv. What happens to the atomic number of an element which emits one alpha particle and a beta particle?
A. Increases by 1 B. stays the same
C. Decreases by 2 D. decreases by 1

v. The half-life of a certain isotope is 1 day. What is the quantity of the isotope after 2 days?
A. One half B. one quarter C. one eighth D. none of these

vi. When Uranium (92 protons) ejects a beta particle, how many protons are left in the remaining nucleus?
A. 92 protons B. 91 protons C. 90 protons D. 89 protons

vii. Release of energy by the Sun is due to
A. Nuclear fission B. nuclear fusion
C. Burning of gases D. chemical reaction

viii. When a heavy nucleus splits into two lighter nuclei, the process would

Unit # 17 **Atomic & Nuclear Physics** **Guess Papers**

ix. The reason carbon-dating works is that
- A. Plants and animals are such strong emitters of carbon-14
- B. After a plant or animal dies, it stops taking in fresh carbon-14
- C. There is so much non-radioactive carbon dioxide in the air
- D. When a plant or an animal dies.

x. Gamma rays are also called;
A. photons B. electrons C. protons D. positrons

xi. Charge on alpha particle is
A. 2e B. 3e C. 4e D. 5e

xii. Radium -226 has a half life of ;
A. 1820 years B. 1920 years C. 1620 years D. 1600 years

Time Allowed: 2:40 Minutes **Total Marks: 53**

Note: Answer any six parts from Section 'B' and attempt any five parts from Section-C. Attempt any two questions from Section 'D' on the separately provided answer book. Use supplementary answer sheet i.e. Sheet–B if required. Write your answers neatly and legibly

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

i. What is difference between atomic number and atomic mass number? Give symbolical representation of a nuclide.

ii. What do you mean by the term radioactivity? Why some elements are radioactive but some are not?

iii. How can you make radioactive elements artificially? Describe with a suitable example.

iv. What are the three basic radioactive decay processes and how do they differ from each other?

v. Write the alpha decay process for $^{234}_{91}P_a$. Identify the parent and daughter nuclei this decay.

vi. Explain whether the atomic number can increase during nuclear decay. Support your answer with an example.

vii. Is radioactivity a spontaneous process? Elaborate your answer with a simple experiment.

viii. What is meant by background radiations? Enlist some sources of background radiations.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Describe two uses of radioisotopes in medicine, industry or research?

ii. What are two common radiation hazards? Briefly describe the precautions that are taken against them.

iii. Complete this nuclear reaction: $^{235}_{92}U \longrightarrow ^{140}_{54}X + ? + 2^{1}_{0}n$. Does this reaction involve fission or fusion? Justify your answer.

iv. Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. Justify this statement with plausible arguments.

v. A nitrogen nuclide $^{16}_{7}N$? Decays to become an oxygen nuclide by emitting an electron. Show this process with an equation.

vi. Determine which of these radioactive decay processes are possible:

A. $^{214}_{84}Po \longrightarrow ^{214}_{84}Po + ^{4}_{2}He$ B. $^{230}_{90}Th \longrightarrow ^{226}_{88}Ra + ^{4}_{2}He$

C. $^{233}_{91}Pa \longrightarrow ^{233}_{92}U + ^{0}_{-1}\beta$ D. $^{12}_{6}C \longrightarrow ^{14}_{7}N + ^{0}_{-1}\beta$

vii. Is it possible for an element to have different types of atoms? Explain.

b. The half-life of $^{16}_{7}N$ is 7.3 s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotope remaining after this time.

Q.5 a. Describe briefly the processes of fission reaction.

sample will be left after 26 years?

Solution of Guess Paper & Model Paper # 9

(Reduced Syllabus)

SECTION- A (MCQs)

i. A	ii. B	iii. B	iv. C	v. B	vi. D
vii. B	viii. A	ix. B	x. A	xi. A	xii. C

SECTION – B (Marks 18)

Q.2 Attempt any SIX parts from the following. All parts carry equal marks. (6 × 3 = 18)

I. What is difference between atomic number and atomic mass number? Give symbolical representation of a nuclide.

Ans: Difference between Atomic Number and Atomic Mass Number:

Atomic Number:

The number of protons in a nucleus is called the charge number or Atomic number and is denoted by the letter Z. Similarly the number of neutrons in the nucleus is denoted by the letter N.

Atomic Mass Number:

The total number of protons and neutrons in the nucleus is called the Atomic Mass Number and is denoted by the letter A. $A = Z + N$.

Nuclide:

If atomic number of an atom is Z and its Atomic Mass Number is A then this atom is represented by the symbol $^{A}_{Z}X$ which is called a nuclide.

Symbolical Representation of a Nuclide:

Generally an atom is represented by the symbol $^{A}_{Z}X$. For example, nuclide of hydrogen atom having only one proton is $^{1}_{1}H$.

ii. What do you mean by the term radioactivity? Why some elements are radioactive but some are not?

Ans: Natural Radioactivity:

The spontaneous emission of radiation by unstable nuclei is called natural radioactivity, and the elements which emit such radiations are called radioactive elements.

In 1896, Becquerel accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate. He also observed that the radiation had the ability to ionize a gas. Subsequent experiments by other scientists showed that other substances also emitted radiations.

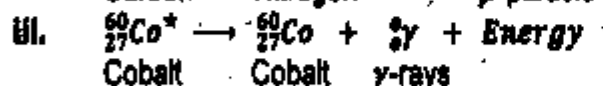
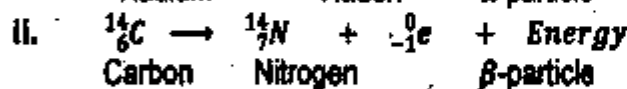
The most significant investigations of this type were conducted by Marie Curie and her husband Pierre.

Some elements are radioactive but some are not:

Some isotopes are stable, but others are radioactive. An isotope will be radioactive if its nuclei are unstable. Large atomic nuclei, with more than 83 protons and their associated complement of neutrons, are inherently unstable. Uranium and plutonium are examples of such elements.

iii. How can you make radioactive elements artificially? Describe with a suitable example.

Ans: Radioactivity is artificially induced through the bombarding atoms of a specific element by radiating particles, thus creating new atoms existing from another type of element.

Examples:

i. $^{226}_{88}Ra \longrightarrow\ ^{222}_{86}Rn + ^{4}_{2}He + Energy$
Radium Radon α-particle

ii. $^{14}_{6}C \longrightarrow\ ^{14}_{7}N + ^{0}_{-1}e + Energy$
Carbon Nitrogen β-particle

iii. $^{60}_{27}Co^{*} \longrightarrow\ ^{60}_{27}Co + ^{0}_{0}\gamma + Energy$
Cobalt Cobalt γ-rays

iv. What are the three basic radioactive decay processes and how do they differ from each other?

Ans: **See Q3. (a), Past FBISE Paper (2015), Page # 103.**

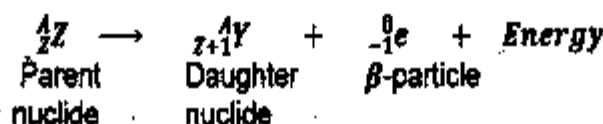
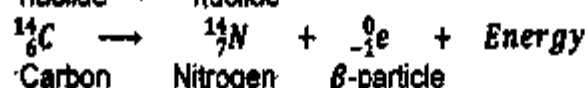
v. Write the alpha decay process for $^{234}_{91}Pa$. Identify the parent and daughter nuclei this decay.

Ans: **See Q2. (ix), Past FBISE Paper (2019), Page # 128.**

vi. Explain whether the atomic number can increase during nuclear decay. Support your answer with an example.

Ans: Beta (β)-decay:

Yes, in beta (β)⁻ decay, the parent nuclide has its proton number Z increased by 1 but its mass number or nucleon number *A* remains unchanged.

General Equation:

$$^{A}_{Z}Z \longrightarrow\ ^{A}_{Z+1}Y + ^{0}_{-1}e + Energy$$
Parent nuclide Daughter nuclide β-particle

Example:

$$^{14}_{6}C \longrightarrow\ ^{14}_{7}N + ^{0}_{-1}e + Energy$$
Carbon Nitrogen β-particle

vii. Is radioactivity a spontaneous process? Elaborate your answer with a simple experiment.

Ans: The spontaneous process is something that occurs naturally and without the aid of outside energy.

Yes, radioactive decay is an example of a spontaneous process as the rate of decay is unaffected by external environment factors such as temperature or pressure.

Experiment:

In 1896, Becquerel accidentally discovered that uranium salt crystals emit an invisible radiation that can darken a photographic plate. He also observed that the radiation had the ability to ionize a gas. Subsequent experiments by other scientists showed that other substances also emitted radiations.

Result: Therefore radioactivity is a spontaneous process because it occurs naturally and without the aid of outside energy.

viii. What is meant by background radiations? Enlist some sources of background radiations.

Ans: Background Radiations:

Radiations present in atmosphere due to different radioactive substances are called background radiations.

Sources of Background Radiations:

Everywhere in rocks, soil, water, and air of our planet are traces of radioactive elements. This natural radioactivity is called the background radiation. It is as much part of our environment as sunshine and rain. Fortunately, our bodies can tolerate it. Only places where radiation is very high can be injurious to health.

Cosmic Radiation:

The Earth, and all living things on it also receive radiation from outer space. This radiation is called

Muons:

An unstable subatomic particle of the same class as an electron (a lepton), but with a mass around 200 times greater. Muons make-up much of the cosmic radiation reaching the earth's surface.

SECTION – C (Marks 15)

Q.3 Attempt any FIVE parts from the following. All parts carry equal marks. (5 × 3 = 15)

i. Describe two uses of radioisotopes in medicine, industry or research?

Ans: Uses of Radioisotopes:

Radioisotopes are frequently used in medicine, industry and agriculture for variety of useful purposes. Following are few applications of radioisotopes in different fields.

Uses of Radioisotopes in Medicine:

Tracers:

Radioactive tracers are chemical compounds containing some quantity of radioisotope. They can be used to explore the metabolism of chemical reactions inside the human body, animal or plant. Radioisotopes are used as tracers in medicine, industry and agriculture.

For example, radio **Iodine-131** readily accumulates in the thyroid gland and can be used for the monitoring of thyroid functioning.

For the diagnosis of brain tumor **phosphorous-32** is used. The malignant part of the body absorbs more quantity of isotopes, and this helps in tracing the affected part of the body.

Uses of Radioisotopes in Industry:

In industry tracers can be used to locate the wear and tear of the moving parts of the machinery.

They can be used for the location of leaks in underground pipes. By introducing a suitable radioactive tracer into the pipe, the leak can be conveniently traced from higher activity in the region of crack in the pipe.

In agriculture radio phosphorous-32 is used as a tracer to find out how well the plants are absorbing the phosphate fertilizer which are crucial to their growth.

ii. What are two common radiation hazards? Briefly describe the precautions that are taken against them.

Ans: Hazards of Radiations:

Some of the harmful effects on human beings due to large doses, or prolonged, small doses of radiations are:

i. Radiation burns, mainly due to beta and gamma radiations, which may cause redness and sore son the skin.
ii. Sterility (i.e. inability to produce children).
iii. Genetic mutations in both human and plants. Some children are born with serious deformities.
iv. Leukemia (cancer of the blood cells).
v. Blindness or formation of cataract in the eye.

Safety Measures/Precautions:

Because we cannot detect radiations directly, we should strictly follow safety precautions, even when the radioactive sources are very weak.

i. The sources should only be handled with tongs and forceps.
ii. The user should use rubber gloves and hands should be washed carefully after the experiment.
iii. All radioactive sources should be stored in thick lead containers.
iv. Never point a radioactive source towards a person.
v. Frequent visits to the radiation sensitive areas should be avoided.

iii. Complete this nuclear reaction: $^{235}_{92}U \longrightarrow {}^{140}_{54}X + ? + 2^{1}_{0}n.$

Does this reaction involve fission or fusion? Justify your answer.

Ans: $^{235}_{92}U \longrightarrow {}^{140}_{54}Xe + {}^{94}_{38}Sr + 2^{1}_{0}n + \text{Energy}$

Uranium Xenon Strontium Neutron

It is the fission reaction because in this process heavy nucleus ($^{235}_{92}U$) breaks into two nearly equal parts with the release of large energy.

iv. Nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction. Justify this statement with plausible arguments.

Ans: Fusion has potential advantages as a safe, sustainable (able to be maintained at a certain rate or level) and environmentally attractive source of energy for electricity generation.

- No runaway reactions or large uncontrolled releases of energy are possible. There is no chemical combustion products in a fusion reaction, and therefore no contribution to atmospheric or water pollution.
- No long lived radioactive materials are produced.
- Fusion is appropriate for generating base-load electricity and producing hydrogen in a sustainable, CO_2-free energy mix.

Therefore nuclear fusion reaction is more reliable and sustainable source of energy than nuclear fission chain reaction.

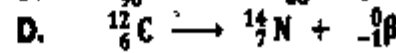
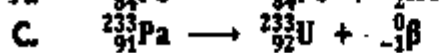
v. A nitrogen nuclide $^{16}_{7}N$? Decays to become an oxygen nuclide by emitting an electron. Show this process with an equation.

Ans: $^{16}_{7}N \longrightarrow \, ^{16}_{8}O + \, ^{0}_{-1}e + Energy$

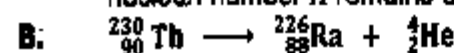
Nitrogen Oxygen β-particle

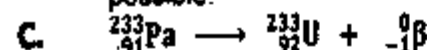
vi. Determine which of these radioactive decay processes are possible:

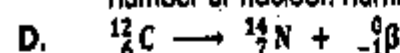
A. $^{214}_{84}Po \longrightarrow \, ^{214}_{84}Po + \, ^{4}_{2}He$ B. $^{230}_{90}Th \longrightarrow \, ^{226}_{88}Ra + \, ^{4}_{2}He$

C. $^{233}_{91}Pa \longrightarrow \, ^{233}_{92}U + \, ^{0}_{-1}\beta$ D. $^{12}_{6}C \longrightarrow \, ^{14}_{7}N + \, ^{0}_{-1}\beta$

Ans: A. $^{214}_{84}Po \longrightarrow \, ^{214}_{84}Po + \, ^{4}_{2}He$

The proton number or atomic number Z of the parent nuclide does not change. Also its mass number or nucleon number A remains unchanged. Therefore radioactive decay process is not possible.

B: $^{230}_{90}Th \longrightarrow \, ^{226}_{88}Ra + \, ^{4}_{2}He$

It is alpha decay because the proton number or atomic number Z of the parent nuclide reduces by 2 and its mass number or nucleon number A decreases by 4. Therefore radioactive decay process is possible.

C. $^{233}_{91}Pa \longrightarrow \, ^{233}_{92}U + \, ^{0}_{-1}\beta$

It is beta (β) – decay because the parent nuclide has its proton number Z increased by 1 but its mass number or nucleon number A remains unchanged. Therefore radioactive decay process is possible.

D. $^{12}_{6}C \longrightarrow \, ^{14}_{7}N + \, ^{0}_{-1}\beta$

The proton number or atomic number Z of the parent nuclide increased by 2 which is not possible. Therefore radioactive decay process is not possible.

vii. Is it possible for an element to have different types of atoms? Explain.

Ans: Yes, it is possible and it is called Isotopes. In Isotopes the number of neutrons is different but number of protons and electrons remain same of a particular atom. Hence atomic number remains same but atomic number changes and new atoms form. Like Hydrogen have 3 Isotopes.

SECTION – D (Marks 20)

Note: Attempt any two questions. All questions carry equal marks. **(2 × 10 = 20)**

Q.4 a. What do you understand by half-life of a radioactive element?

Ans: See Q5. (a), Past FBISE Paper (2019), Page # 131.

b. The half-life of $^{16}_{7}N$ is 7.3 s. A sample of this nuclide of nitrogen is observed for 29.2s. Calculate the fraction of the original radioactive isotope remaining after this time.

Solution: $Half\ Life\ of\ ^{16}_{7}N = 7.3\ s$; $Time\ observed = t = 29.2\ s$

$Remaining\ fraction\ of\ original\ radioactive\ isotope = ?$

$$Number\ of\ Half\ Lives\ for\ sample = \frac{29.2}{7.3} = 4$$

$If\ N_0 is\ a\ orignal\ fraction\ then\ after\ 4\ half\ lives:$

Remaining atoms = Original atoms × $1/2^t$

$$N = N_0 \times 1/2^4$$
$$\frac{N}{N_0} = \frac{1}{16}$$

Hence $\frac{1}{16}th$ of the original sample will be left.

Q.5 a. Describe briefly the processes of fission reaction.

Ans: See Q5. (a), Past FBISE Paper (2014), Page # 98.

b. Carbon-14 has a half-life of 5730 years. How long will it take for the quantity of carbon-14 in a sample to drop to one-eighth of the initial quantity?

Solution: Half life of Carbon-14 is $T_{1/2} = 5730$ years.

$$\frac{N}{N_0} = \frac{1}{8} \Rightarrow \frac{N}{N_0} = \frac{1}{2^t} \Rightarrow \frac{1}{8} = \frac{1}{2^t}$$
$$2^t = 8 \Rightarrow 2^t = 2^3 \Rightarrow t = 3$$

Sample will drop to one-eighth ($\frac{1}{8}th$) of the initial quantity in three half lives.

Time for first half life $1\,T_{1/2} = 5730$ years.

Time for 2nd half life $2\,T_{1/2} = 2 \times 5730 = 11460$ years.

Time for 3rd half life $3\,T_{1/2} = 3 \times 5730 = 17190$ years $= 1.72 \times 10^4$ years

Hence $\frac{1}{8}th$ of the original sample will be left after the 1.72×10^4 years.

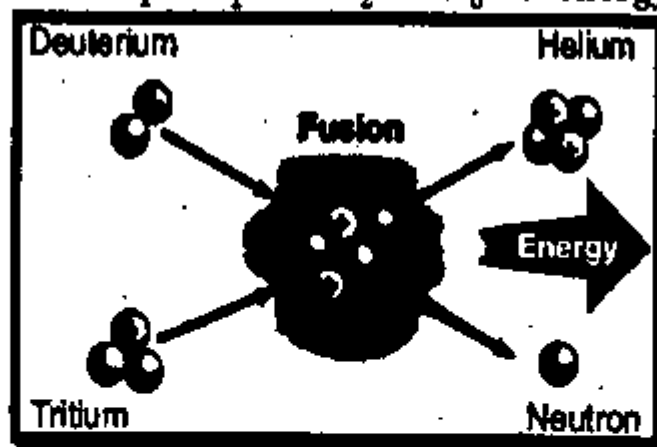
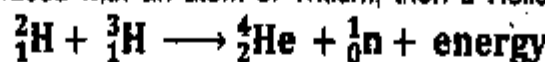
Q.6 a. Describe briefly the processes of fusion. What is the source of solar energy.

Ans: Nuclear Fusion:

A process in which two light nuclei diffuse to form a heavier nucleus with release of enormous amount of energy is called fusion reaction.

The mass of the final nucleus is always less than the masses of the original nuclei. According to mass-energy relation ($E = mc^2$) this loss of mass converts into energy.

Reaction during Fusion:

If an atom of Deuterium is fused with an atom of Tritium, then a Helium nucleus or alpha article is formed as given by
$$^2_1\text{H} + {}^3_1\text{H} \longrightarrow {}^4_2\text{He} + {}^1_0\text{n} + \text{energy}$$

Source of Solar Energy:

Energy coming from the Sun and stars is supposed to be the result of fusion of hydrogen nuclei into Helium nucleus with release of energy. The temperature at the centre of the Sun is nearly 20 million Kelvin which makes the fusion favorable. According to this reaction four hydrogen nuclei fuse together to form a helium nucleus along with two positrons, three alpha particles, and 25.7 Me V of energy.

b. Cobalt-60 is a radioactive element with half-life of 5.25 years. What fraction of the original sample will be left after 26 years?

IMPORTANT QUESTIONS & ANSWERS

Q1. Technetium-99 m is a radioactive element and is used to diagnose brain, thyroid, liver and kidney diseases. This element has half-life of 6 hours. If there is 200 mg of this technetium present, how much will be left in 36 hours.

Solution: *Half Life of* Technetium – 99 m = 6 *hours*

Given amount of Technetium – 99 m = 200 *mg* ; *Amount left after* 36 *hours* = ?

Remaining amount = Original amount × $1/2^t$ or $N = N_0 \times 1/2^t$

$$N = 200 \times 1/2^6 \Longrightarrow N = \frac{200}{64} = 3.125\ mg$$

Q2. Half-life of a radioactive element is 10 minutes. If the initial count rate is 368 counts per minute, find the time for which count rates reaches 23 counts per minute.

Solution: Half life of radioactive element $= T_{1/2} = 10\ mins.$

Initial count rate = 368 *counts per minute* ; Final count rate = 23 *counts per minute* ; Time taken = ?

The initial count rate is 368, therefore,

$$368 \xrightarrow{10\ \text{min.}} \frac{368}{2} = 184 \xrightarrow{10\ \text{min.}} \frac{184}{2} = 92 \xrightarrow{10\ \text{min.}} \frac{92}{2} = 46 \xrightarrow{10\ \text{min.}} \frac{46}{2} = 23$$

Therefore this process takes 4 half-lives.

Time taken = Number of half lives × duration of half life

Time taken = 4 × $T_{1/2}$; Time taken = 4 × 10 ; Time taken = 40 *minutes*

Q3. Ashes from a campfire deep in a cave show carbon-14 activity of only one-eighth the activity of fresh wood. How long ago was that campfire made?

Solution: Activity of C-14 from ashes = $\frac{1}{8}$th ; Half life of C-14 = $T_{1/2}$ = 5730 years ; Time = t = ?

Since activity of C-14 from ashes is $\frac{1}{8}$th of fresh wood, hence 3 half-lives have been elapsed, during this period therefore

Time = *number of half – lives* × $T_{1/2}$ ⇒ t = 3 × 5730 ⇒ = 17190 *years*.

Q4. What nuclear reaction would release more energy, the fission reaction or the fusion reaction? Explain.

Ans: Fusion reaction release more energy than fission. The energy per nucleon is much greater in fusion than in fission.

It has been estimated that in this p-p chain reaction (*proton–proton chain reaction*), 25.7 MeV energy is given out i.e., 6.4 MeV per nucleon energy is obtained which is much greater than the energy given out per nucleon (1 MeV) during a fission reaction.

Q5. Which has more penetrating power, alpha particle or gamma ray photon?

Ans: Alpha particle has the least penetrating power, beta is next and Gamma has most penetrating power. Gamma ray is charge less and massless photon that's why they have more penetrating power than alpha particle which have charge and mass and interact with matter so have less penetrating power.

Q6. What is the difference between natural and artificial radioactivity?

Ans: In natural radioactivity and atomic nuclei want to became stable that's why they emit some radiations and such atoms are called radioactive and the process is called natural radioactivity.

In artificial radioactivity the atomic nuclei which are not excited but we excite them by bombarding neutrons or protons and after excitation of nuclei the atom become radioactive and emit radiation this is called artificial radioactivity.

Q7. How long would you likely have to wait to watch any sample of radioactive atoms

Q8. Which type of natural radioactivity leaves the number of protons and the number of neutrons in the nucleus unchanged?

Ans: If gamma ray emit from the excited nucleus then only energy of the nucleus releases but atomic number and atomic mass remain same.

$${}^{A}_{Z}X^{*} \longrightarrow {}^{A}_{Z}X + \gamma$$

Parent nuclide — Daughter nuclide — γ-particle

Example:

$${}^{60}_{27}Co^{*} \longrightarrow {}^{60}_{27}Co + {}^{0}_{0}\gamma + Energy$$

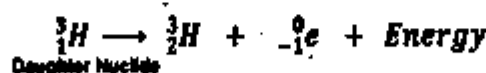
Cobalt — Cobalt — γ-rays

Q9. Tritium ${}^{3}_{1}H$ is radioactive isotope of hydrogen. It decays by emitting an electron. What is the daughter nucleus?

Ans:

$${}^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e + Energy$$

$${}^{3}_{1}H \longrightarrow {}^{3}_{2}H + {}^{0}_{-1}e + Energy$$

Daughter Nuclide

Q10. What information about the structure of the nitrogen atom can be obtained from its nuclide ${}^{14}_{7}N$? In what way atom in ${}^{14}_{7}N$ is different from the atom in ${}^{16}_{7}N$?

Ans: The nuclide ${}^{14}_{7}N$ is one of the isotopes of nitrogen atom. It has 7 protons, 7 electrons and 7 neutrons. Whereas ${}^{16}_{7}N$ isotope has two extra neutrons in its nucleus as its atomic mass number increases by 2.

Q11. What do you understand by nuclear transmutations?

Ans: Nuclear Transmutations:

During natural radioactivity an unstable nucleus of radioactive element disintegrates to become more stable,

The spontaneous process in which a parent unstable nuclide hanges into a more stable daughter nuclide with the admission of radiations is called nuclear transmutation.

Q12. Describe the Characteristic of three types of Radiations.

Ans: Characteristic of three types of Radiations.

Alpha (α) Particles:

Positively charged particles (helium nuclei) ejected at high speed with a range of only a few centimetres in air. They can be stopped by an ordinary sheet of thin aluminium foil.

Beta (β) Particles:

Streams of high-energy electrons ejected at various speeds as high as close to the speed of light. Beta particles may be able to penetrate several millimetres of aluminium.

Gamma (γ) Rays:

Electromagnetic radiation of very short wavelength. Their wavelengths and energies can vary. High-energy gamma rays can penetrate at least 30 cm of lead or 2 km of air.